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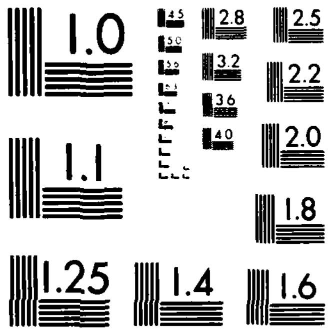

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INTERNAL FORCED CONVECTION TO LOW PRANDTL NUMBER GAS MIXTURES

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Prepared by

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30 JUNE 1984

ENGINEERING EXPERIMENT STATION
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TUCSON, ARIZONA 85721

Interim Report

INTERNAL FORCED CONVECTION TO LOW PRANDTL NUMBER GAS MIXTURES

by

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At a Prandtl number of about 0.2, the predictions of accepted correlations for heat transfer in fully established tube flow differ by a factor more than two. Since gas turbine systems proposed for propulsion utilize working fluids with the Prandtl number in this range, it was necessary to resolve the discrepancy. By mixing helium with xenon or hydrogen with xenon, the range of $0.16 \lesssim Pr \lesssim 0.7$ can be obtained. Measurements with these mixtures in a vertical tube showed that the Colburn analogy and Dittus-Boelter substantially overpredict the Nusselt number for constant property conditions; best agreement was provided by relations suggested by Petukhov and by Kays. For moderate variation of gas properties ($1 < T_w/T_b \lesssim 2.2$) the correlation for average friction factor by Taylor was verified; the exponent on the Prandtl number in his equation for heat transfer was modified to 0.65 in order to accommodate these new data.

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ABSTRACT

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NOMENCLATURE

A	Flow area of test section;
c	Velocity of sound;
c_p	Specific heat at constant pressure;
c_v	Specific heat at constant volume;
D	Inside diameter
g	Acceleration due to gravity;
g_c	Dimensional conversion factor;
G	Average mass flux, $\dot{m}/A$;
h	Heat transfer coefficient;
i	Specific enthalpy;
k	Thermal conductivity;
$\dot{m}$	Mass flow rate;
L	Distance from start of heating to PT #2;
$\tilde{M}$	Molal mass;
p	Pressure;
q''	Heat flux;
R	Gas constant for a particular gas;
$\mathcal{R}$	Universal gas constant;
T	Temperature ;
x	Axial distance from start of heating;

NOMENCLATURE (continued)

Greek Symbols

ε/κ	Force constant in Lennard-Jones potential;
γ	Ratio of specific heats, c_p/c_v;
μ	Absolute viscosity;
ν	Kinematic viscosity;
ρ	Density;
σ	Force constant in Lennard-Jones potential;

Nondimensional Parameters

f	Friction factor, $g_c\, \rho_{b,av,} D\, \Delta p_{fr}/2\, L\, G^2$;
G_r	Grashof number based on wall heat flux, $g\, D^4\, q''_w/(\nu^2\, k\, T)_i$
Nu	Nusselt number, $h\, D/k$;
$\bar{p}$	Pressure drop, $\rho_i\, g_c\, (p_i - p)/G^2$;
Pr	Prandtl number, $c_p \mu/k$;
q^+	Heat flux parameter, $q''_w/G\, c_{p,i}\, T_i)$;
Re	Reynolds number, $G\, D/\mu$;

NOMENCLATURE (continued)

Subscripts

av	Lengthwise average;
b	Evaluated at bulk temperature;
cp	Constant property condition;
DB	Dittus-Boelter;
fr	Frictional;
H_2	Hydrogen gas;
i	Inlet; an index;
mod	Modified;
ref	Reference;
w	Wall;
Xe	Xenon gas;
1	At start of heating;
2	At pressure tap 2.

INTRODUCTION

The use of gas mixtures has been proposed for use in closed cycle gas turbines with applications in power systems undersea and in space as well as for propulsion of ships, aircraft, buses and rail units. Helium and hydrogen both possess excellent heat transfer properties but require many stages of turbomachinery in closed cycle gas turbines. The addition of higher molecular weight gases to helium or hydrogen to form binary mixtures can reduce the number of stages in turbomachinery but increases heat exchanger surface area because of the lower thermal conductivity of the heavier gases. The Prandtl number can be as low as 0.16 for these mixtures. In the past, most designs utilizing these gas mixtures were made by using correlations of the Colburn [1933] or Dittus-Boelter [1930] type which had resulted from tests using gases with a Prandtl number around 0.7, or with liquids.

In fact, some well-known texts do not recognize that a Prandtl number less than 0.6 can occur for gas mixtures. Several relations have been reported which differ considerably from Colburn and are suggested for use over a wide range of Prandtl numbers, some as low as 0.1 [Kays, 1966; Petukhov, 1970; Sleicher and Rouse, 1975; Gnielinski, 1975; and Churchill, 1977]. The relations recommended by these investigators are tabulated in Table 1. The large variations in Nusselt number resulting from these relations are shown in Fig. 1 as a function of Prandtl number. At a Prandtl number of 0.2 there is a factor of 2.2 between the lowest and

Table 1. Equations Proposed to Predict Nusselt Number over a Range of Prandtl Number.

Investigator	Correlation Equations for Constant Properties	Suggested Pr Range	Eq
Dittus-Boelter [1930]	$Nu = .0021\ Re^{0.8} Pr^{0.4}$	0.7 to 1.0	1
Colburn [1933]	$Nu = 0.023\ Re^{0.8} Pr^{1/3}$	0.5 to 100	2
Kays [1966]	$Nu = 0.022\ Re^{0.8} Pr^{0.6}$	0.5 to 1.0	3
Petukhov [1970]	$Nu = \dfrac{(\xi/8)\ Re\, Pr}{K_1(\xi) + K_2(Pr)\sqrt{\xi/8}\ (Pr^{2/3} - 1)}$ $\xi = (1.82 \log_{10} Re - 1.64)^{-2}$ $K_1(\xi) = 1.3.4\xi \qquad k_2(Pr) = 11.7 + 1.8\ Pr^{-1/3}$	0.5 to 200	4
Sleicher and Rouse [1975]	$Nu = 5.0 + 0.015\ Re^{a}\ Pr^{b}$ $a = 0.88 - 0.24/(4 + Pr)$ $b = 1/3 + 0.5\ \exp(-0.6\ Pr)$	0.1 to 10^5	5
Gnielinski [1975]	$Nu = 0.0214\ (Re^{0.8} - 100)\ Pr^{0.4}\ (T_w/T_b)^{.45}\left[1 + \left(\frac{D}{x}\right)^{2/3}\right]$	0.6 to 1.5	6
Churchill [1977]	$Nu = 6.3\ \dfrac{0.079\ Re\sqrt{f}\ Pr}{[1 + Pr^{4/5}]^{5/6}}$ $\dfrac{1}{\sqrt{f}} = 2.21\ \ln\left(\dfrac{Re}{7}\right)$	all	7

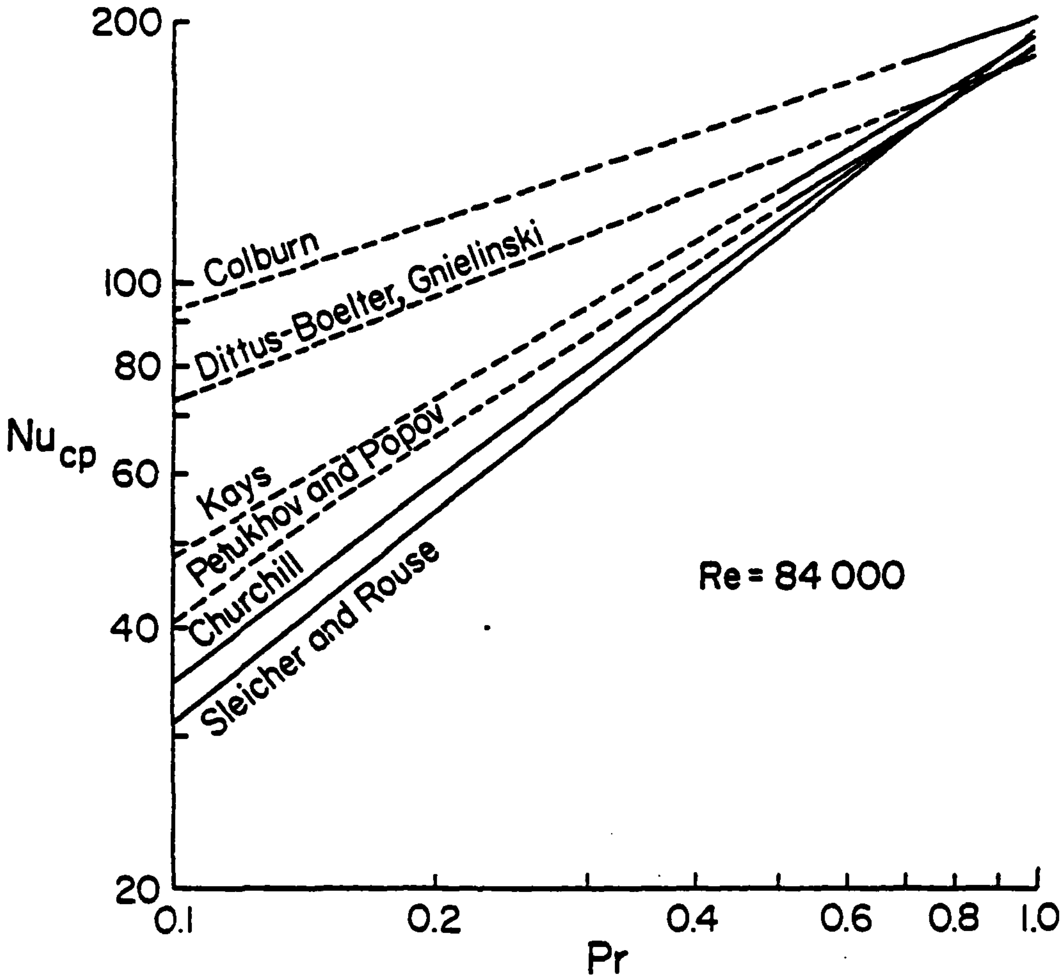

Figure 1. Comparison of correlation equations recommended by several investigators.

highest value recommended! The danger of extrapolating heat transfer correlations based on data at $Pr \approx 0.7$ is emphasized by Pierce [1981] in an application to the closed gas turbine cycle.

The authors of this paper have used a number of binary mixtures of light and heavy gases to test the correlations shown in Fig. 1; for later reference, equation numbers are listed on the table. Pickett, Taylor and McEligot [1979] employed mixtures of helium and argon in order to obtain $Pr \approx 0.42$ and 0.49 while Serksnis, Taylor and McEligot [1978] conducted measurements at $Pr \approx 1/3$ by using a mixture of hydrogen and carbon dioxide. In the present investigation, additional data have been obtained in the range $0.18 \lesssim Pr \lesssim 0.3$ by mixing hydrogen with xenon and helium with xenon. Table 2 summarizes the range of data obtained in this investigation.

TRANSPORT PROPERTIES OF THE MIXTURES

The properties needed for this study were compressibility, viscosity, thermal conductivity, specific heat, enthalpy, speed of sound, and the gas constant. The properties of air have been studied extensively; for the comparison data the NBS tables of Hilsenrath et al. [1955] were used in this investigation. The properties of helium-xenon mixtures were calculated theoretically. For all gases the viscosity and thermal conductivity were assumed to be independent of pressure.

The helium-xenon mixtures were assumed to be ideal gases, thus making the compressibility equal to unity. This assumption is reasonable for the range of pressures (260 - 1000 kPa or 2.6 - 9.9 atm) and

Table 2. Range of Variables in the Present Investigation.

Gas	Air	He-Xe	He-Xe	He-Xe	He-Xe	H_2-Xe
Molecular Weight	28.97	83.8	40	28.3	14.5	29
Inlet Bulk Prandtl Number	0.717	0.251	0.214	0.231	0.301	0.181 (0.196)
Experimental Runs	16	10	10	4	5	4
Inlet Bulk Reynolds Number	33,900 - 85,800	32,600 - 87,400	34,300 - 61,800	48,400 - 55,400	34,000 - 40,900	71,100 - 73,900
Exit Bulk Reynolds Number	21,600 - 77,900	16,500 - 74,300	19,200 - 51,800	26,200 - 43,000	19,500 - 36,700	43,400 - 66,700
Maximum T_w/T_b	2.38	2.22	1.99	2.06	2.04	1.78
Maximum T_w (°K)	974	962	941	982	972	832
Maximum q^+	0.0044	0.0069	0.0053	0.0051	0.0047	0.0034
Maximum Gr/Re_i^2	1.40×10^{-2}	1.44×10^{-2}	9.34×10^{-3}	6.67×10^{-3}	3.05×10^{-3}	3.29×10^{-3} (3.04×10^{-3})
Maximum Mach Number	0.109	0.123	0.079	0.90	0.075	0.103
x/D for Local Bulk Nusselt Numbers	2.2 - 52.4	2.2 - 52.4	2.2 - 52.4	2.2 - 52.4	2.2 - 52.4	2.2 - 52.4

Values in parentheses are for calculated thermal conductivities of H_2 - Xe

temperatures (290 - 980°K or 62 - 1310°F) used in this experiment. Since helium and xenon are monatomic and the temperature range in this study was not too large, the relation [Reynolds, 1968]

$$c_p = (5/2)\ R = (5/2)\mathcal{R}/\tilde{M} \tag{8}$$

was used to calculate the specific heat.

Using the ideal gas and constant specific heat assumptions, one may derive simple equations for the enthalpy and speed of sound [Reynolds and Perkins, 1968]

$$\begin{aligned} & i = c_p = (T - T_{ref}) \\ \text{and} \quad & c = \sqrt{\gamma RT} = \sqrt{(5/3)RT} \end{aligned} \tag{9}$$

The Lennard-Jones (6-12) potential can be employed in the Chapman-Enskog kinetic theory to predict thermal conductivity, viscosity and Prandtl number of binary mixtures of inert gases [Hirschfelder, Curtiss and Bird, 1964]. There has been considerable experimental study of the pure gases but, unfortunately, few data exist on the mixtures.

With force constants, ε/k and σ, suggested by Hirschfelder, Curtiss and Bird [1964], the predicted viscosity for pure helium falls about eight percent below the data of Clarke and Smith [1968], Dawe and Smith [1970] and Kalelkar and Kestin [1970] at temperatures around 900°C (1650°F). Likewise, the predicted thermal conductivity is about nine percent lower than the measurements of Saxena and Saxena [1968] up to 1100°C (2011°F). In contrast, using the force constants suggested by DiPippo and Kestin

[1969] leads to essential agreement with the values recommended by the Thermophysical Properties Research Center [Touloukian and Ho, 1970].

For pure xenon, force constants from Hirschfelder, Curtiss and Bird [1964] predicted viscosity that falls about five percent below the data of Dawe and Smith [1970] and Kestin, Ro and Wakeham [1972]. The predicted thermal conductivity is about twelve percent lower than measurements of Saxena and Saxena [1969] up to 1200°C (2191°F). DiPippo and Kestin did not report force constants for xenon, but Kestin, Ro and Wakeham suggested force constants that predicted values of viscosity that are in very good agreement with the experimental data and predicted values of thermal conductivity that are about four percent lower than the reported measurements.

The properties of the helium-xenon mixtures are shown in Fig. 2. The solid curves were calculated using the force constants recommended by DiPippo and Kestin [1969] for helium: $\sigma = 2.158$ Å and $\varepsilon/k = 86.2$°K and those recommended by Kestin, Ro and Wakeham [1972] for xenon: $\sigma = 2.858$ A and $\varepsilon/k = 285.2$°K.

The viscosity of the mixtures varies considerably with the molecular weight of the mixture. At 277°C (530°F) the maximum viscosity of the mixture is 41% higher than that of helium and five percent higher than xenon. Viscosity predicted using constants from DiPippo and Kestin [1969] and Kestin, Ro and Wakeham [1972] agrees to within three percent of the data of Trautz and Heberling [1923] and Thornton [1960]. As with pure gases the viscosity increases with temperature.

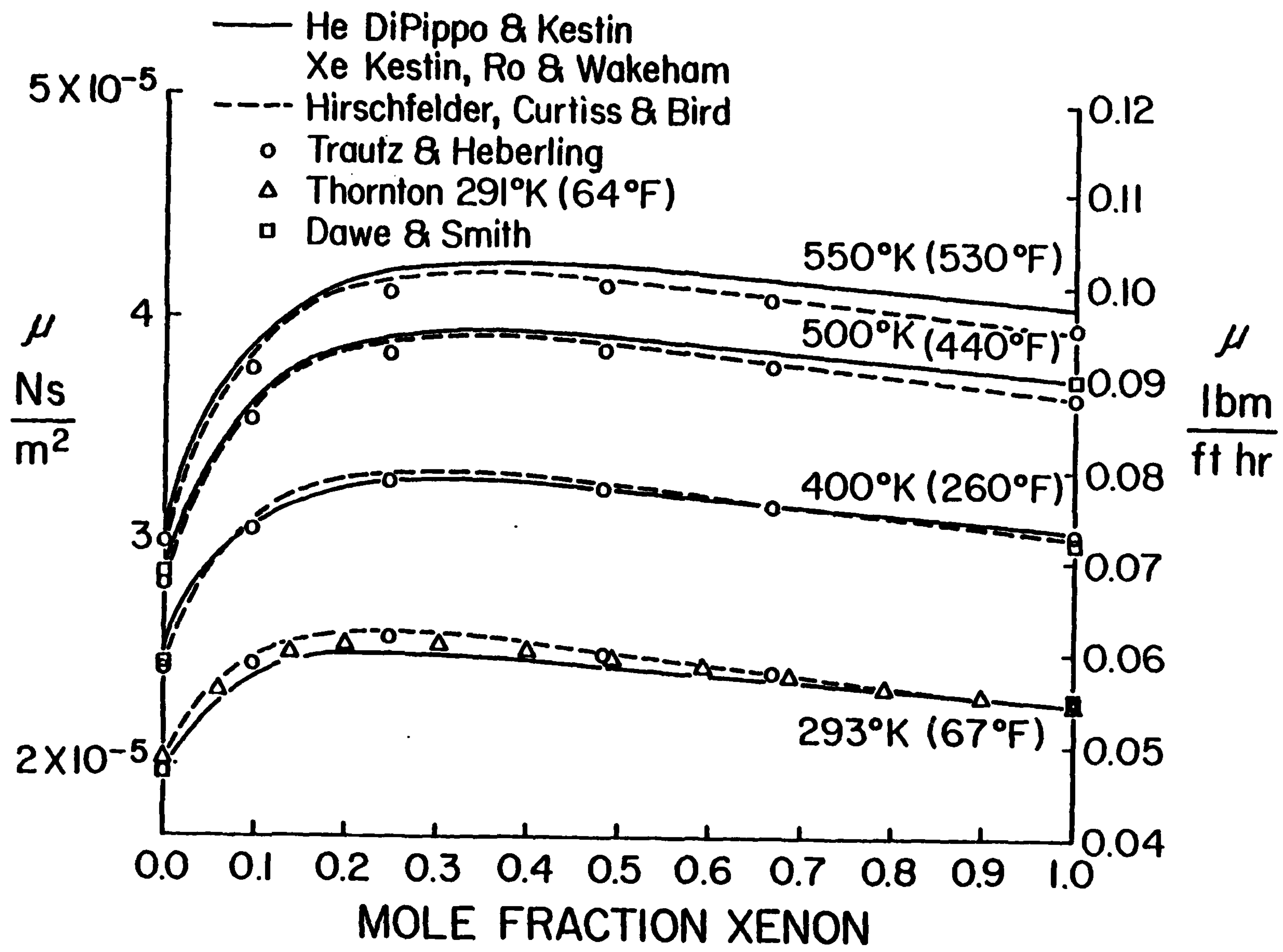

Figure 2a. Transport properties of helium-xenon mixtures. Pressure = 1atm.

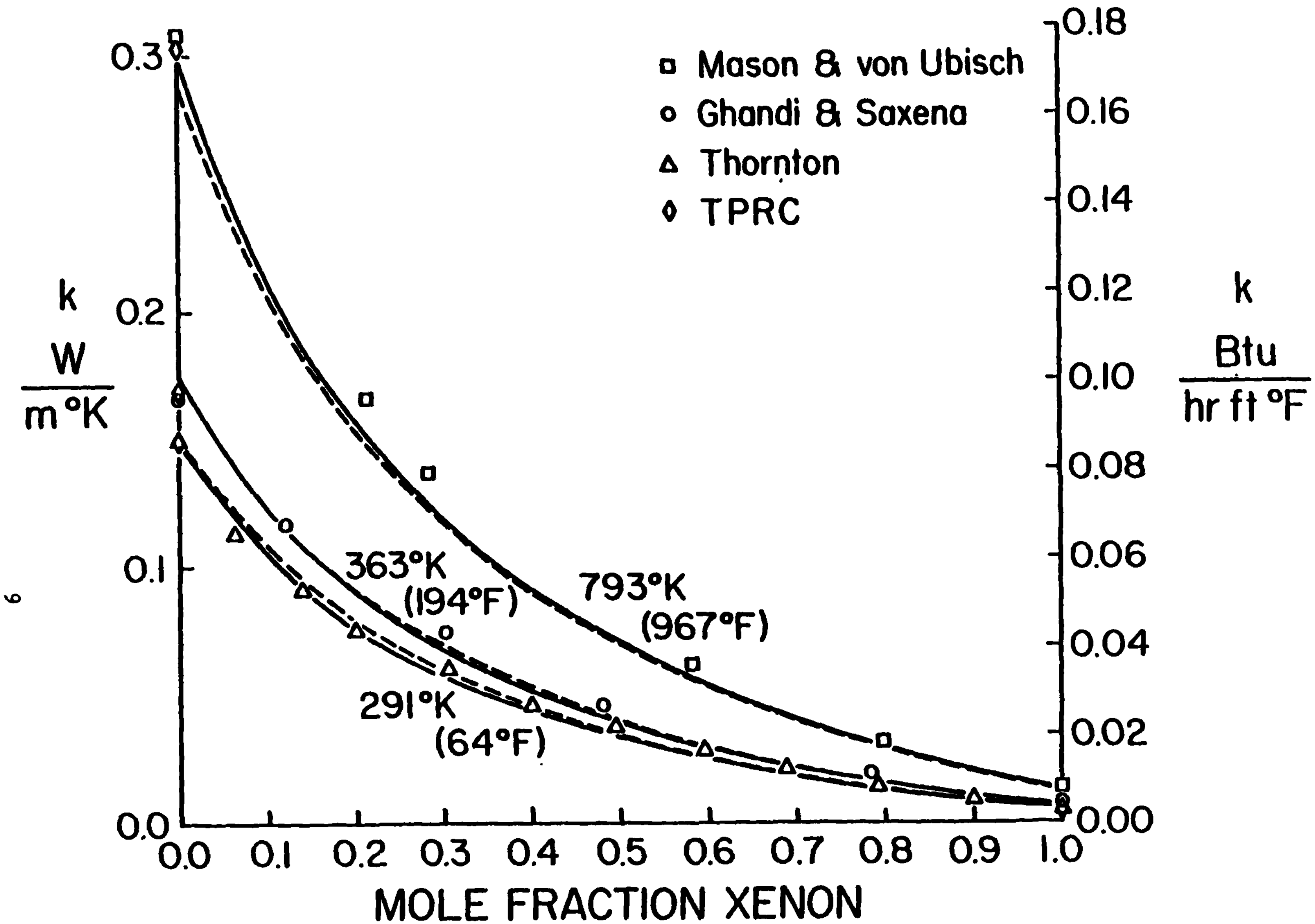

Figure 2b. Transport properties of helium-xenon mixtures.
Pressure = 1atm.

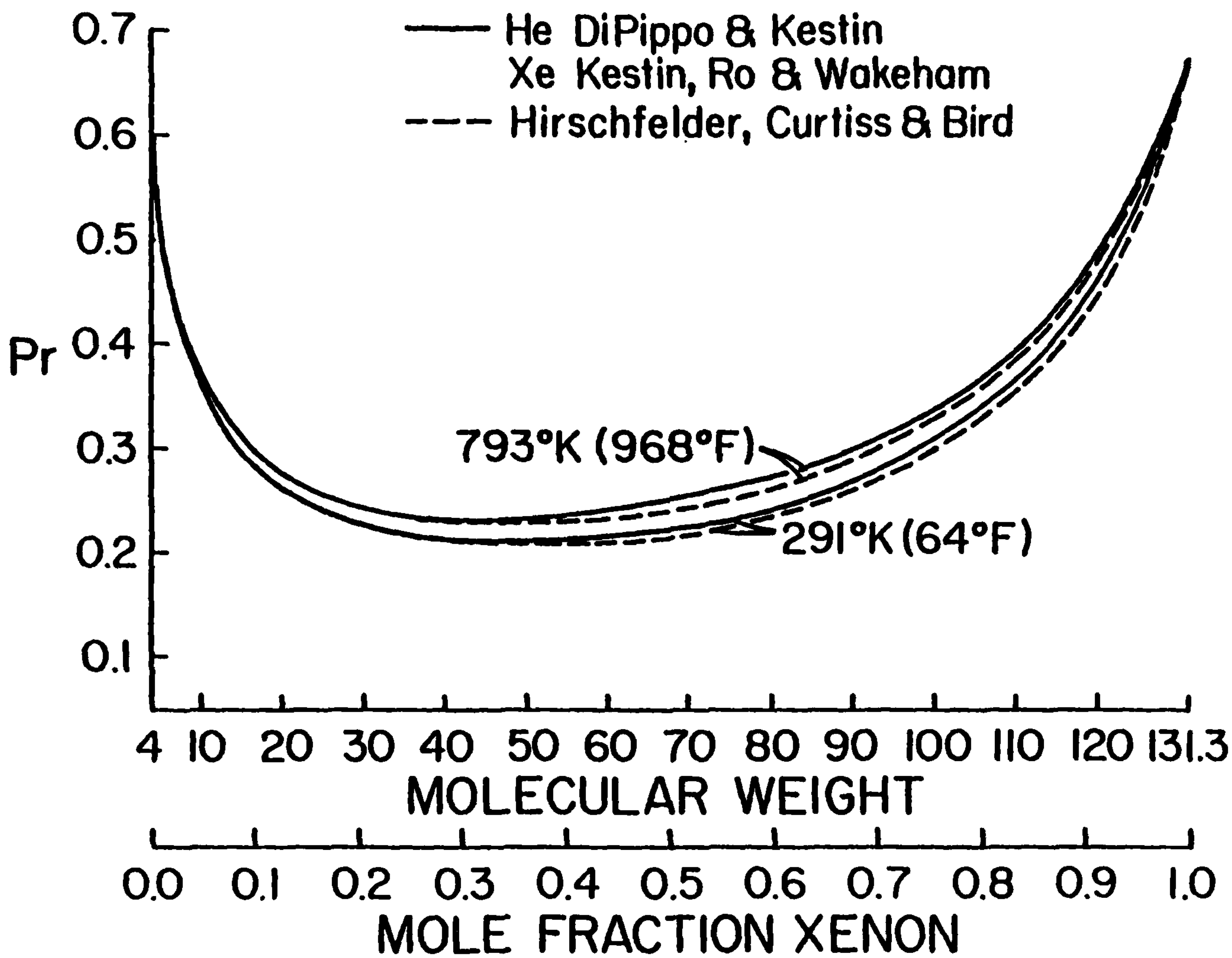

Figure 2c. Transport properties of helium-xenon mixtures.
Pressure = 1atm.

The mixture thermal conductivity decreases by a factor of 23 as the molecular weight increases from pure helium to pure xenon over the range of mixture temperature in this investigation, and mixture conductivity also increases with temperature. Agreement with the data of Thornton [1960], Gandhi and Saxena [1968] and Mason and von Ubish [1960] is good for temperatures ranging from 18° to 90°C (65° to 194°F). The only data available at higher temperatures are those of Mason and von Ubish at 520°C (968°F) and these are almost 10% higher than the predictions; however, in a critical review Gandhi and Saxena [1968] have observed that the measurements of Mason and von Ubish appear to be systematically higher than others they reviewed.

As a consequence of the variation of thermal conductivity and specific heat vs. molecular weight the Prandtl number decreases to a minimum of about 0.21 at $\tilde{M} \approx 50$ from about 0.667 for the pure gases. It is about 0.23 at the molecular weight of air.

It is interesting to note that even though the force constants of Hirschfelder, Curtiss and Bird [1964] did not adequately predict thermal conductivity and viscosity for pure helium and xenon, their predictions for the mixtures did not differ greatly from the ones used in this investigation.

The hydrogen-xenon mixtures were also assumed to be ideal gases, making the compressibility equal to unity. This assumption is also reasonable for the range of pressures (750 - 800°KPa or 7.4 - 7.9 atm) and temperatures (290 - 830°K or 62 - 1040°F) used in this experiment. The specific heat of this mixture was calculated by the relation

$$c_{p,mixture} = (\text{mass fraction}_{H_2})\, c_{p,H_2} + (\text{mass fraction}_{Xe})\, c_{p,Xe}$$

The enthalpy and speed of sound were calculated in the same manner as with the helium-xenon mixture.

The hydrogen-xenon mixture properties are shown in Fig. 3. The solid lines for viscosity were calculated using the viscosities of hydrogen and xenon and the method recommended by Hirschfelder, Curtiss and Bird [1964] for calculating mixtures of monatomic gases. Hydrogen is, of course, polyatomic and predicting its properties is more complex than predicting those of monatomic gases. The solid lines for thermal conductivity were calculated using the method of Lindsay and Bromley [1965].

The only measurements of viscosity of hydrogen-xenon mixtures found in the literature were those of Trautz and Heberling [1934] which are in good agreement with these predictions, especially at the mole fraction of xenon (0.21) in the mixture used in the present investigation. The viscosity of the mixture increases with temperature and the increase in viscosity from pure hydrogen to pure xenon is threefold.

The mixture thermal conductivity decreases by a factor of 30 as the molecular weight increases from pure hydrogen to pure xenon over the temperature range of this investigation. Only two investigations of thermal conductivity of hydrogen-xenon mixtures have been reported. Barua [1960] measured conductivities for mixtures of eight volume-percentages of xenon from 0 to 100% at temperatures of 30°C (85°F) and 45°C (111°F).

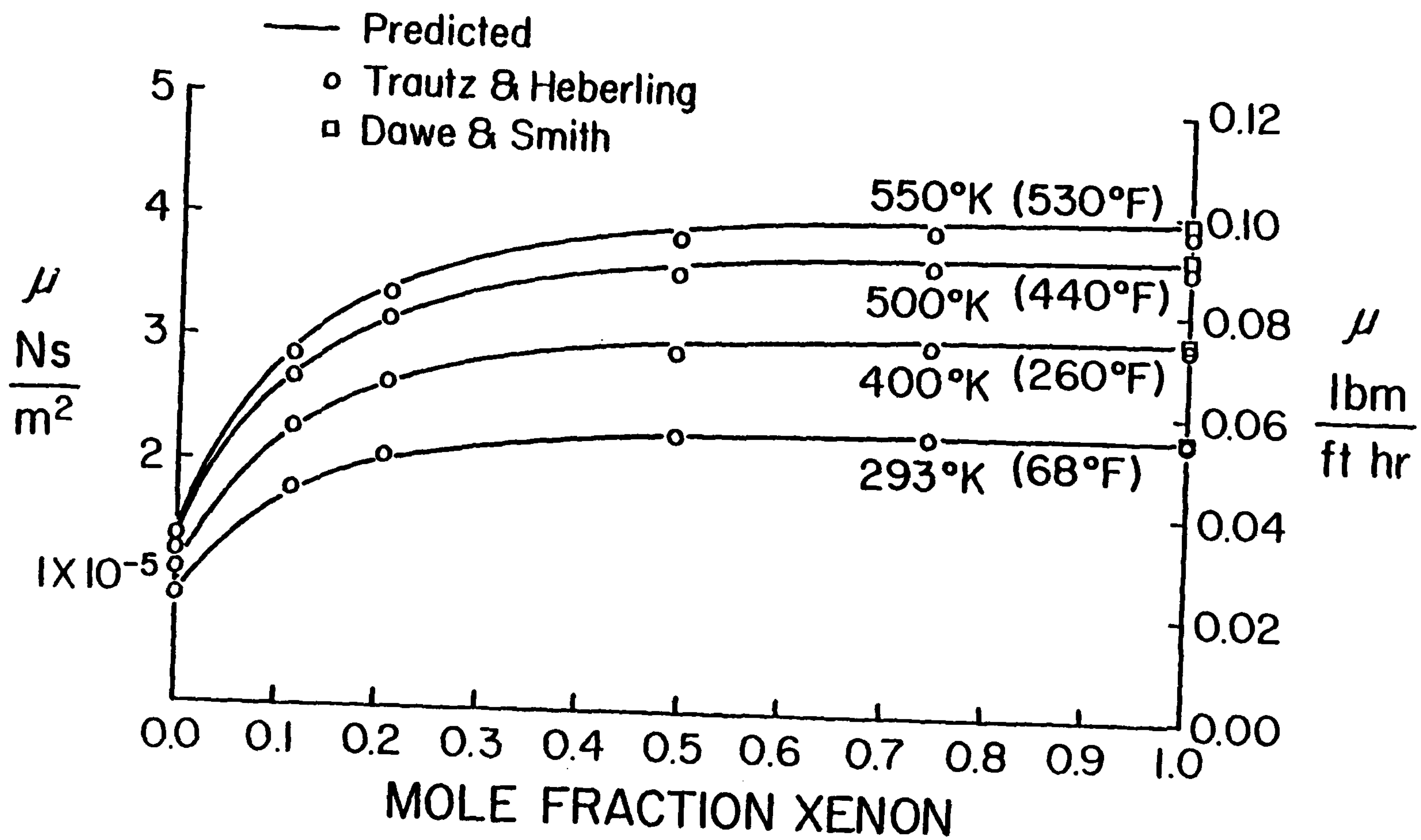

Figure 3a. Transport properties of hydrogen-xenon mixtures. Pressure = 1atm.

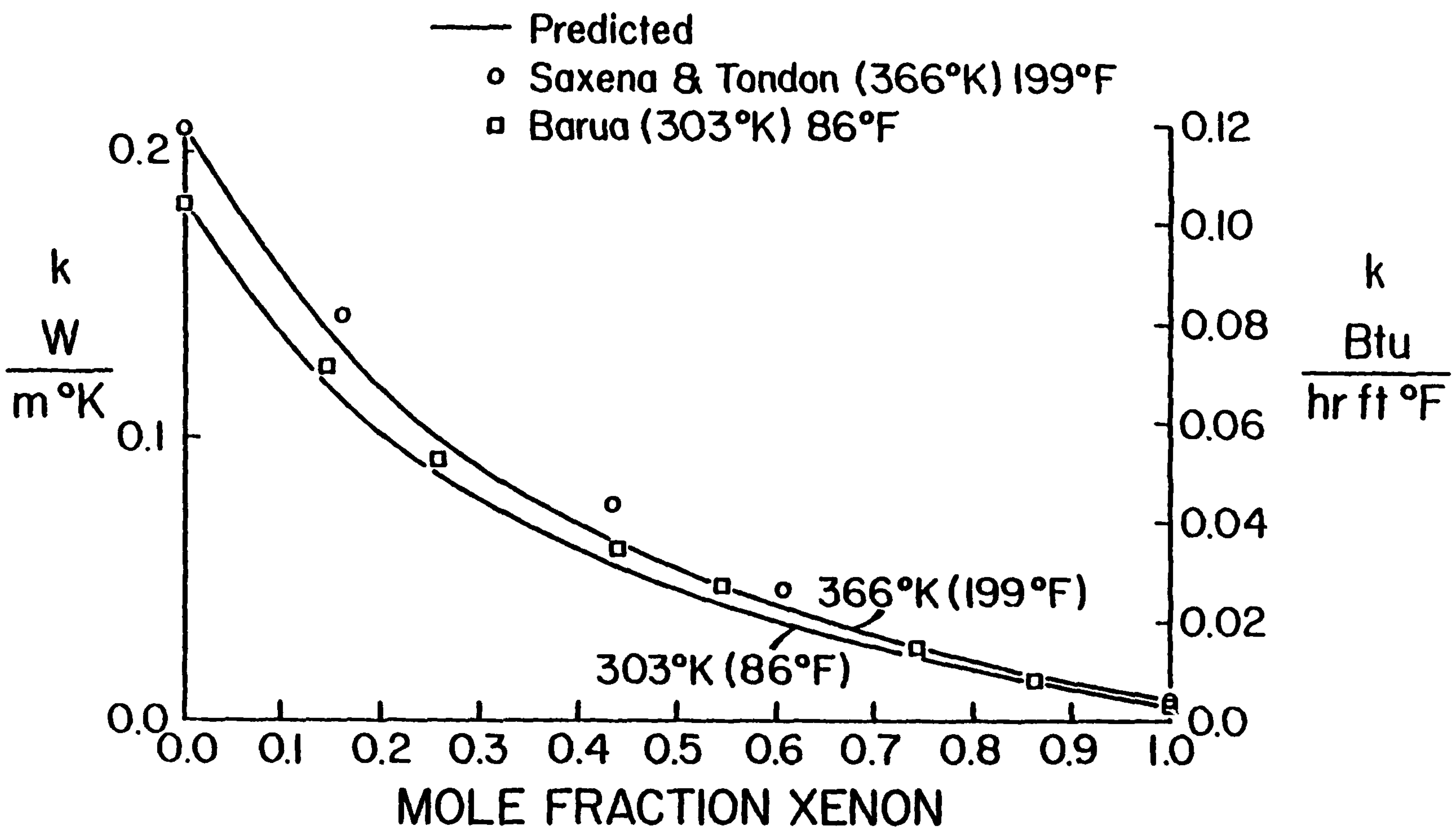

Figure 3b. Transport properties of hydrogen-xenon mixtures. Pressure = 1atm.

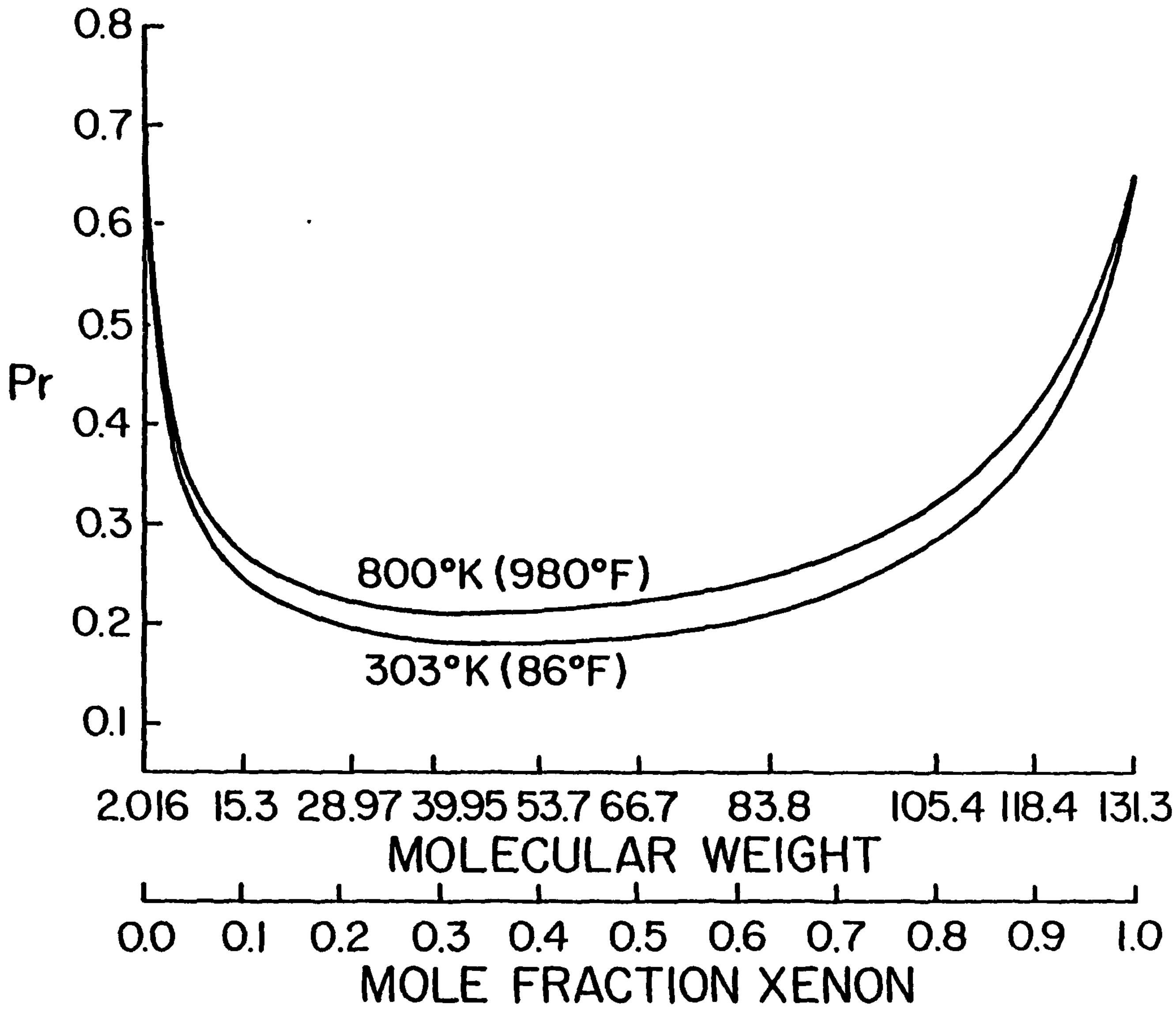

Figure 3c. Transport properties of hydrogen-xenon mixtures.
Pressure - 1atm.

Saxena and Tondon [1971] measured conductivities for five mole fractions of xenon from 0 to 1.0 at 40°, 65° and 93°C (104°, 149° and 199°F). The measurements of the two investigations are in good agreement with each other, particularly near the mixture concentration (mole fraction of Xe = 0.21) used in this investigation, but are as much as fifteen percent higher than predicted values at 93°C (199°F).

For the present concentration, the experimental values of thermal conductivity were extrapolated to the maximum mixture temperature used, and it was found that the measured conductivity was twenty percent higher than the predicted value. A method recommended by Kestin [personal communication, 1983], but not with complete confidence, is described by Clifford et al. [1980]. The thermal conductivities calculated by this method are closer to the experimental values than those predicted by the method of Lindsay and Bromley, but are still fifteen percent lower at 283°C. As a consequence of this discrepancy in thermal conductivity, the heat transfer data of this investigation were reduced twice, once using the lower predicted values and once using the values obtained by extrapolating the experimental values. The normalized Nusselt number was found to be six to ten percent higher when the calculated thermal conductivity was used rather than the extrapolated experimental value.

As a result of the variations of the calculated thermal conductivity, viscosity and specific heat versus the molecular weight, the calculated Prandtl number decreases to a minimum of about 0.18 at $\tilde{M} = 47$ from 0.707 for hydrogen and 0.667 for xenon. It is about 0.20 at $\tilde{M} = 29$ which is the molecular weight of both air and the hydrogen-xenon mixture

used in this investigation. When based on the experimental thermal conductivity a value of 0.18 is predicted for this mixture.

THE EXPERIMENT

Apparatus

The experimental apparatus, arrangement and procedure were similar to those used by Park, Taylor and McEligot [1982]. In the present investigation the loop was a closed circuit, as shown in Fig. 4, due to the extremely high cost of the xenon gas. A single-acting "Gas Booster Pump" from Haskel Manufacturing Company circulated the gas mixtures through two pressure regulators, a plenum, a cooler which removed the heat of compression, a tubular flowmeter, the instrumented test section, another cooler to remove the energy added in the heated test section, a UGC densitometer, another plenum, a control valve and then back into the pump. The two pressure regulators and plenum were installed to remove the pressure fluctuations in the flow created by the pump. Two pressure transducers were used to measure the pressure fluctuations; a Model SCD 147 from Data Instruments, Inc. was located just beyond the first cooler and a Kulite Model XT-140-100G subminiature pressure transducer was mounted flush with the inside of the tube immediately beyond the elbow at the entry of the test section to measure the pressure fluctuations of the flow entering the test section.

The vertical test section was a circular tube of Inconel 600 with an inside diameter of 5.87 mm (0.231 in) and a wall thickness of 0.28 mm

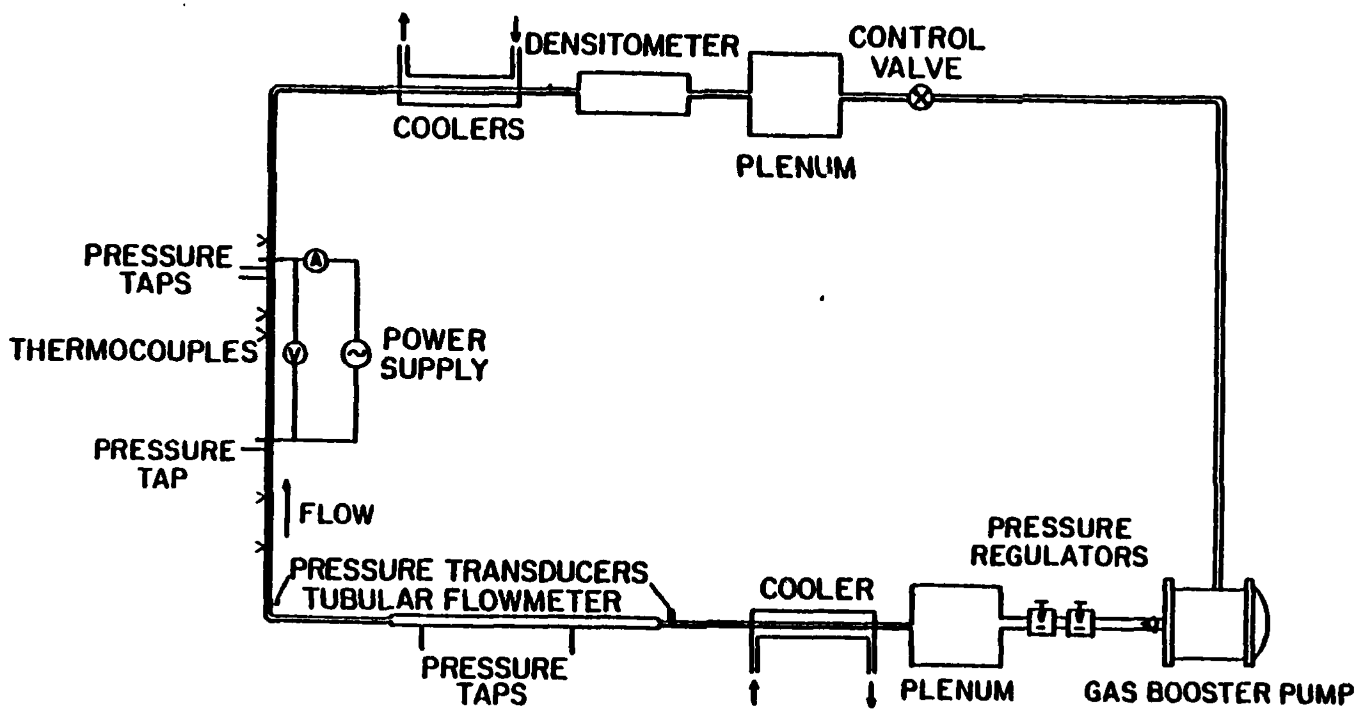

Figure 4. Schematic diagram of experimental apparatus.

(0.011 in). It consisted of a heated section 60 diameters in length preceded by an unheated section of 56 diameters which insured that the flow approached a fully developed velocity profile prior to heating. The test section itself served directly as an electrical resistance heater. Alternating current from a line voltage stabilizer was supplied via variable transformers to the test section through thin stainless steel electrodes brazed to the tube. The current was measured using a Weston current transformer and a Weston Model 370 ammeter. A high impedance Fluke differential voltmeter measured the voltage across the test section to serve as a check on power measurements. Three pressure taps, with holes of about 0.30 mm (0.012 in.) were used. One was located 5 diameters below the lower electrode and the other two were 50 and 54 diameters above it, near the upper electrode. The static pressure at the test section inlet was measured with a Heise bourdon tube gauge and the pressure drop between taps was measured with an MKS Baratron Type 77 Pressure Meter and Head. The fluctuating signals from the Kulite pressure transducer were recorded on a Hewlett-Packard x-y recorder.

Twenty-one premium grade Chromel-Alumel thermocouples, 0.13 mm (0.005 in.) in diameter were spot welded to the heated section of the tube using the parallel junction technique suggested by Moen [1960]. Thermal conduction error was calculated from the heat loss calibration data and a relation developed by Hess [1965]; the thermocouple conductance was estimated from the emissivity of the bare wire and a natural convection correlation for small Rayleigh numbers [Kreith, 1973]. The correction was of the order of 1% of the difference between the tube temperature and the

environmental temperature; at Re ~ 3 x 10^4 this correction was equivalent to 1-1/2 to 2% in the Nusselt number.

Procedures and Preliminary Measurements

The test section was a bare tube surrounded by a draft shield so the heat loss was by radiation and natural convection. The heat loss was calibrated as a function of axial position and temperature from measurements with a vacuum on the inside of the test section. the uncertainty of the heat loss measurements was estimated to be about 1%. The heat loss data were represented by cubic equations that deviated no more than three percent except at very low test section temperatures 121°C (250°F) where the deviation might be as much as ten percent. For tests with gas flow the heat loss was usually less than 10% of the heat generated. A few runs with inlet Reynolds number less than 36000 and maximum wall temperatures greater than 650° (1200°F) had heat losses exceeding 20% of the heat generated. The worst case was a heat loss of 41% for helium-xenon ($\tilde{M} \simeq 83.8$) with an inlet Reynolds number of 34000 and a maximum wall temperature of 680°C (1256°F). The electrical resistance of the test section was also measured as a function of temperature during the heat loss runs; the estimated uncertainty was also about 1%.

The closed loop was pressurized with gases and gas mixtures from high pressure cylinders. A cylinder of helium-xenon gas mixture with a molecular weight of 83.8 was obtained from the NASA-Lewis Research Center. Helium-xenon mixtures of lesser molecular weight were obtained in the loop by adding helium to the existing gas mixture. On the other hand, the

hydrogen-xenon mixture was obtained by mixing high purity hydrogen directly with high purity xenon. The partial pressures of the gases in a mixture were used to calculate the quantity of helium needed to reduce the molecular weight of the helium-xenon mixture and also to determine the amounts of hydrogen and xenon needed to obtain the particular mixture for a given run.

The UGC gas densitometer was calibrated with air, argon, helium and the helium-xenon gas mixture ($\tilde{M} = 83.8$) over the pressure range of this investigation. The densitometer was used to verify the procedures for mixing the gases to predetermined concentrations in situ and also for checking the concentrations after a series of runs. This was done by comparing the measured density with the density calculated using the measured temperature and pressure and the perfect gas law. The measured and calculated densities usually agreed within one percent and the mixture molecular weight did not change measurably during the runs. Mass flow rate was determined with the tubular flowmeter, which was itself calibrated over the range of interest using several positive displacement meters in parallel. The mass flow rate could be determined within an uncertainty of 1.5% or better.

Park, Taylor and McEligot [1982] reported the results of an experiment on the effects of pulsating flow on heat transfer with air with the same apparatus modified to an open loop configuration, so that the mass flow rate could be measured directly with positive displacement meters at the exit of the loop. The static pressure fluctuations were as large as could be attained with the gas booster pump in this system (9 to 35%).

Frequency ranged from 2.1 to 3.6 Hertz, q^+ from zero to 0.0034 and Reynolds numbers from 18,000 to 102,000. For the range of conditions in the present investigation the effect of pressure fluctuations from 26 to 35% had less than a 2% effect on the Nusselt number [Park, Taylor and McEligot, 1982]. The pressure fluctuations in the gas mixtures were never more than 0.6% (usually less than 0.2%) and had a frequency no greater than 2.0 Hertz. Thus, any effect of pressure fluctuations on the Nusselt number of the present gas mixture experiments is believed to be negligible. Results from runs made with air pulsating at the present levels in the closed loop compared closely with those from similar runs conducted with the loop open and no pressure fluctuations.

The procedure for the experimental runs was to introduce the proper amounts of the gases into the closed loop and then circulate the mixture until the density of the gas reached steady state as measured by the densitometer. The mass flow rate was set to give the required Reynolds number, and then the electrical power to the test section was adjusted to give a series of maximum wall temperatures of approximately 120°C (250°F), 260°C (500°F), 400°C (750°F), 540°C (1000°F) and 680°C (1250F). After covering the range of wall temperature the mass flow rate could be changed to give the next required Reynolds number. Once the range of Reynolds number was covered, the power was shut down and the gas flow stopped. At this time the density was again measured to determine whether the molecular weight had changed due to preferential leakage of the hydrogen or helium. No change in molecular weight could be detected at any time during the experiment.

During each run the wall temperatures along the heated and unheated test section were recorded along with the inlet static pressure and the pressure difference across both the tubular flow meter and the heated test section. The current through the test section and the voltage drop were recorded. The bulk temperature of the gas entering the tubular flow meter was measured and the temperature of the gas entering the heated test section was deduced from this measured temperature and the wall temperatures of the unheated section just downstream of the start of heating.

The data were reduced to give local heat transfer and fluid flow parameters. As described later in the Experimental Results, the ratio of measured Nusselt number to the Nusselt number predicted by Dittus and Boelter [1930] was plotted as a function of the ratio of wall-to-bulk gas temperature and was then extrapolated to $T_w/T_b = 0$ to deduce a constant property Nusselt number versus position for each gas mixture and Reynolds number. This constant property Nusselt number was compared to the predicted values suggested by several investigators mentioned earlier. The heat transfer and friction data with property variation were reduced and compared with existing correlations.

Experimental Uncertainties:

The experimental uncertainties were estimated by the method of Kline and McClintock [1953]. Typical uncertainties for the Nusselt number were about 8% at $x/D \simeq 1.3$ decreasing to 5% at $x/D > 24$ for low heating rates, and about 1.4% at $x/D \simeq 1.3$ increasing to 4% at $x/D < 24$ for the

higher heating rates. These estimates are in good agreement with the estimates made by Serksnis [1977] for H_2 - CO_2 experiments and by Pickett [1976] for He-Ar experiments, both in open loop configurations. For the low heating rates, the dominant uncertainties are provided by the inlet bulk gas temperature and the wall temperatures. For higher heating rates, the uncertainty increases with x/D because the uncertainties in tube wall temperature and, therefore, temperature difference increase significantly with temperature level, while the contributions of uncertainties in mass flow rate, electrical power and inlet gas temperature remain small. Typical uncertainties for air, He-Xe ($\tilde{M} \simeq 40$) and H_2-Xe ($\tilde{M} \simeq 29$) data are shown in Table A2 in Appendix A.

Reproducibility

The reproducibility of the measurement technique was checked in two ways. Air data in steady flow had been obtained previously in two other test sections by Serksnis, Taylor and McEligot [1978] and Pickett, Taylor and McEligot [1979]. It was found that each had a series of runs at Re_i near 80,000 and various heating rates, so these were compared to present measurements at the same conditions. For the three sets of data which spanned a five-year period, it was found that in the downstream region the normalized Nusselt number, $Nu/(0.021Re^{0.8}\,Pr^{0.4})$, agreed to within three percent at low heating rates ($T_w/T_b \simeq 1.2$) and within two percent at higher heating rates ($1.4 < T_w/T_b < 1.8$).

Secondly, the reproducibility of the present measurements was tested at the end of the experiments by duplicating one of the first runs

with $Re_i \simeq 60,000$, $q^+ = 0.0014$ (maximum $T_w/T_b \simeq 1.5$) and steady conditions. The mass flow rate could be reproduced to better than 0.2%, the test section inlet pressure to within less than 0.1% and the electrical current within the accuracy of ammeter ($\simeq 0.25\%$). The resulting values of $(T_w - T_{b,in})_{max}$ differed by 2.1%, leading to agreement of the fully developed Nusselt numbers within less than 3% again.

EXPERIMENTAL RESULTS

The ranges of the present data have been previously presented as Table 2. Tabulations of these data are provided in Appendix B. Data for helium-argon mixtures are tabulated in the report by Pickett [1976] and for hydrogen-carbon dioxide mixtures by Serksnis [1977].

Heat Transfer with Constant Properties

To compare experimental data with constant property correlations the measurements were extrapolated to the constant property idealization by an approach like that of Malina and Sparrow [1964]. For this method, a series of experimental runs was taken with the same inlet Reynolds number and gas composition but with successively higher heating rates. At each thermocouple location the normalized value of the measured Nusselt number, Nu/Nu_{DB}, was plotted versus the local ratio of wall to bulk temperature, T_w/T_b. An extrapolation to $T_w/T_b = 1$ yielded the deduced Nusselt number for constant property conditions, Nu_{cp}.

For fully developed conditions with air as the fluid, the ratio of Nu_{cp}/Nu_{DB} was about 0.94 for Reynolds numbers from about 34,000 to 85,000 without any apparent dependence on Reynolds number. The variations of Nu_{cp}/Nu_{DB} with T_w/T_b for several thermocouple locations are shown in Figure 5 for air and three binary gas mixtures. It can readily be seen that the extrapolated values of Nu_{cp}/Nu_{DB} decrease from 0.94 for a Prandtl number of 0.72 to 0.86 at Pr = 0.42, 0.76 at Pr = 0.21 and 0.66 at the lowest Prandtl number. This reduction in the normalized value corresponds to the trend predicted by an analysis by Pickett, Taylor and McEligot [1979].

The constant property Nusselt numbers for Prandtl numbers from 0.18 to 0.72 for three Reynolds numbers are compared to various correlations from references from Dittus-Boelter [1930] through Churchill [1977] in Figure 6. The solid symbols denote data from the present investigation. The air data from Pickett [1976] and Serksnis [1977] and the present investigation agreed to within less than 3% and are represented by a single solid symbol. As the Reynolds number increases, the deviation between the predictions of various correlations also increases. At Reynolds numbers of 34,000 and 60,000 there is little difference between the values predicted by Kays [1966] and Petukhov and Popov [Petukhov, 1970], and both are in reasonably good agreement with the experimental data for Prandtl numbers from about 0.2 to 0.72. However, for a Reynolds number of 84,000, the difference between th Petukhov and Popov and Kays' correlations widens and the Petukhov relation agrees more closely with experiments at the lower Prandtl number.

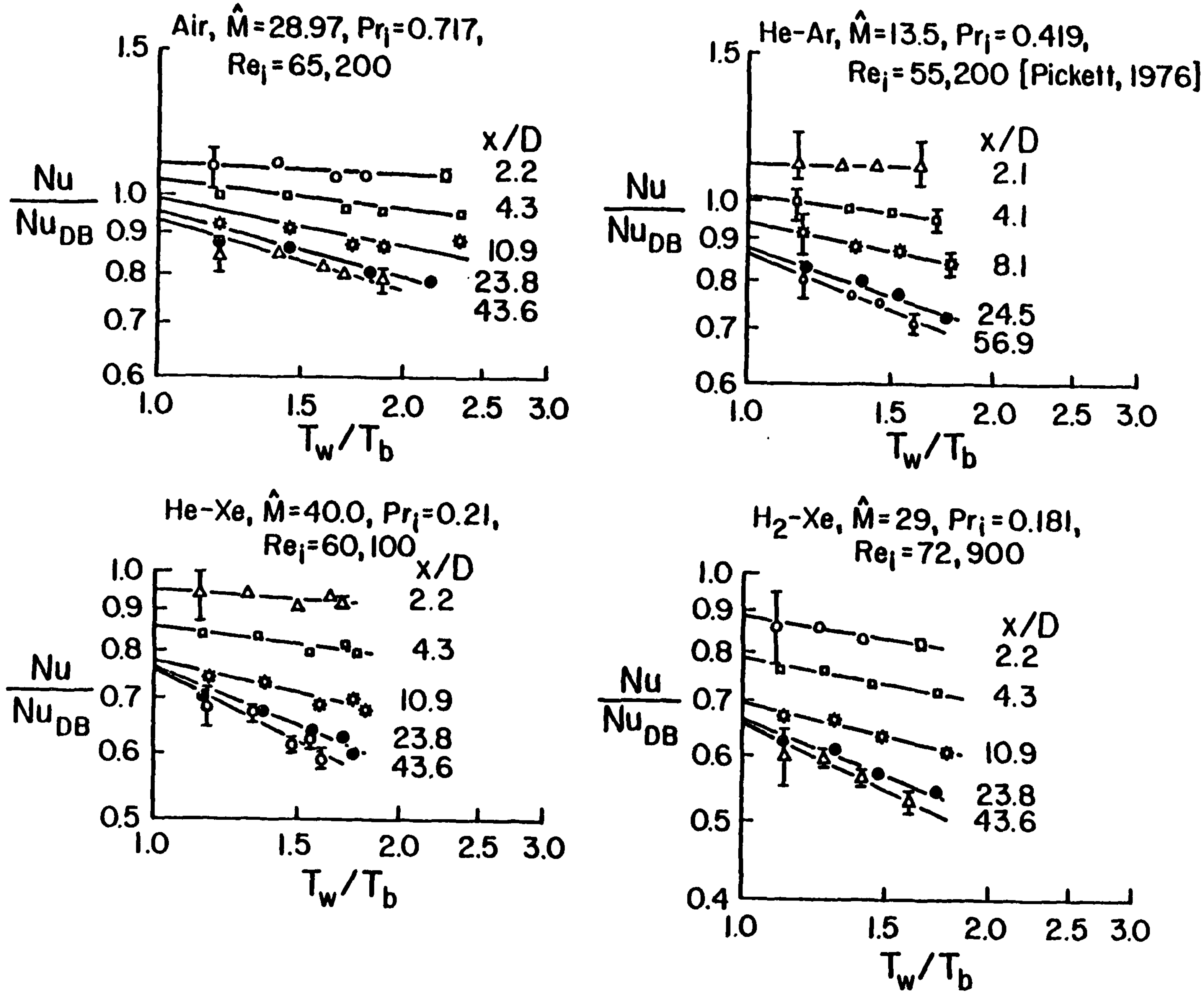

Figure 5. Technique for determining constant property Nusselt number.

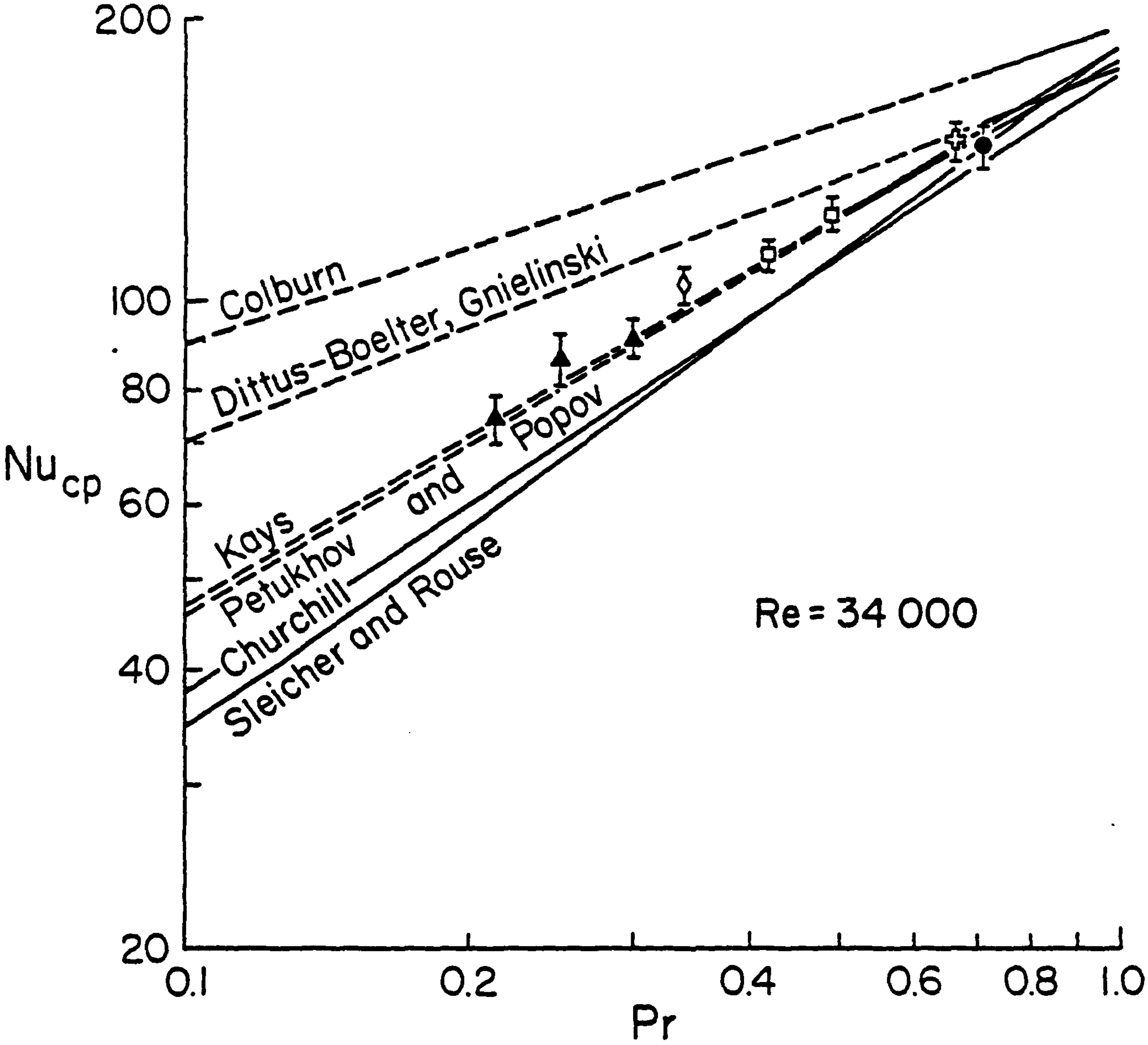

Figure 6a. Comparison between measured Nusselt number and Nusselt number predicted by correlations proposed by other investigators for constant properties.

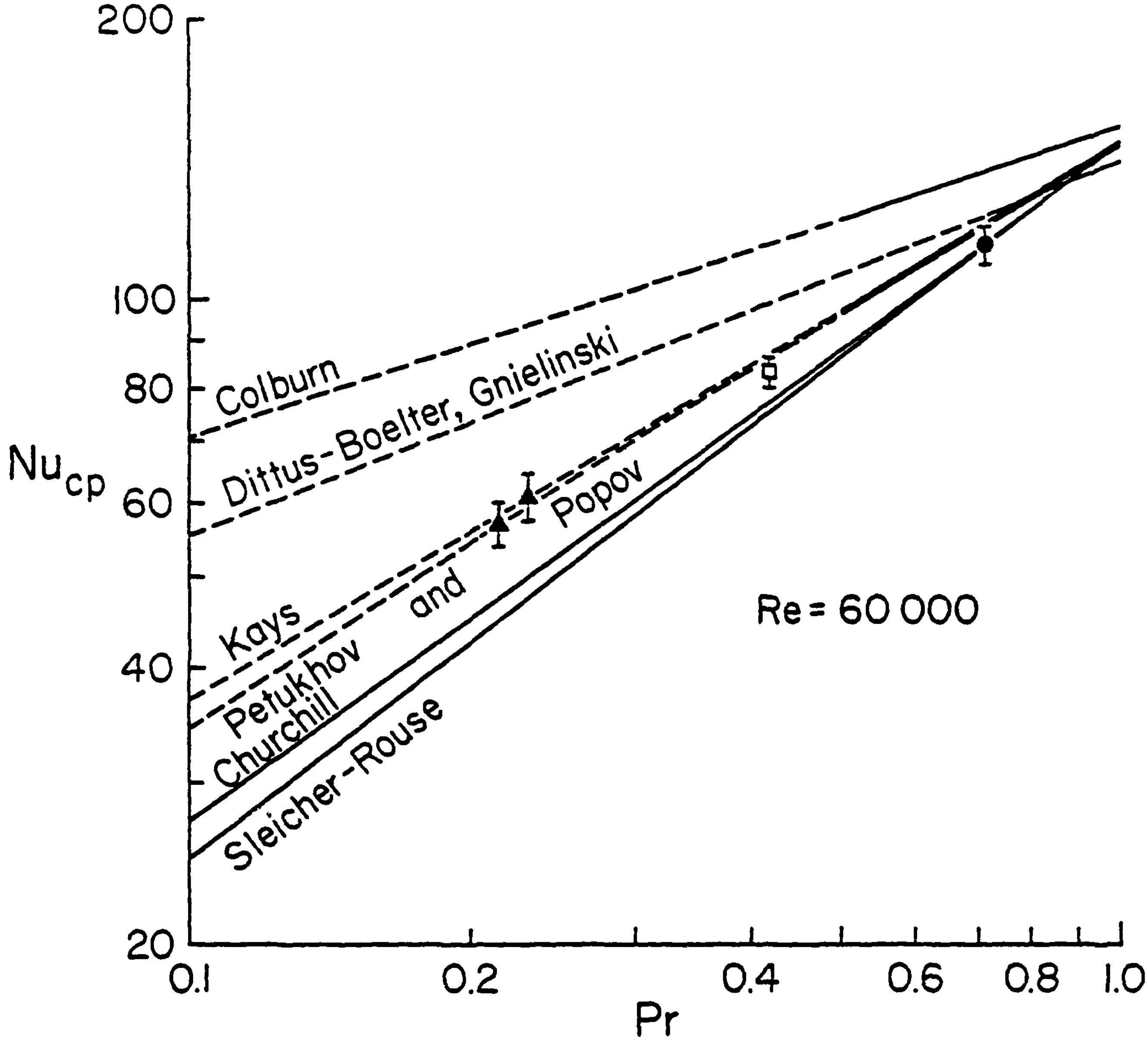

Figure 6b. Comparison between measured Nusselt number and Nusselt number predicted by correlations proposed by other investigators for constant properties.

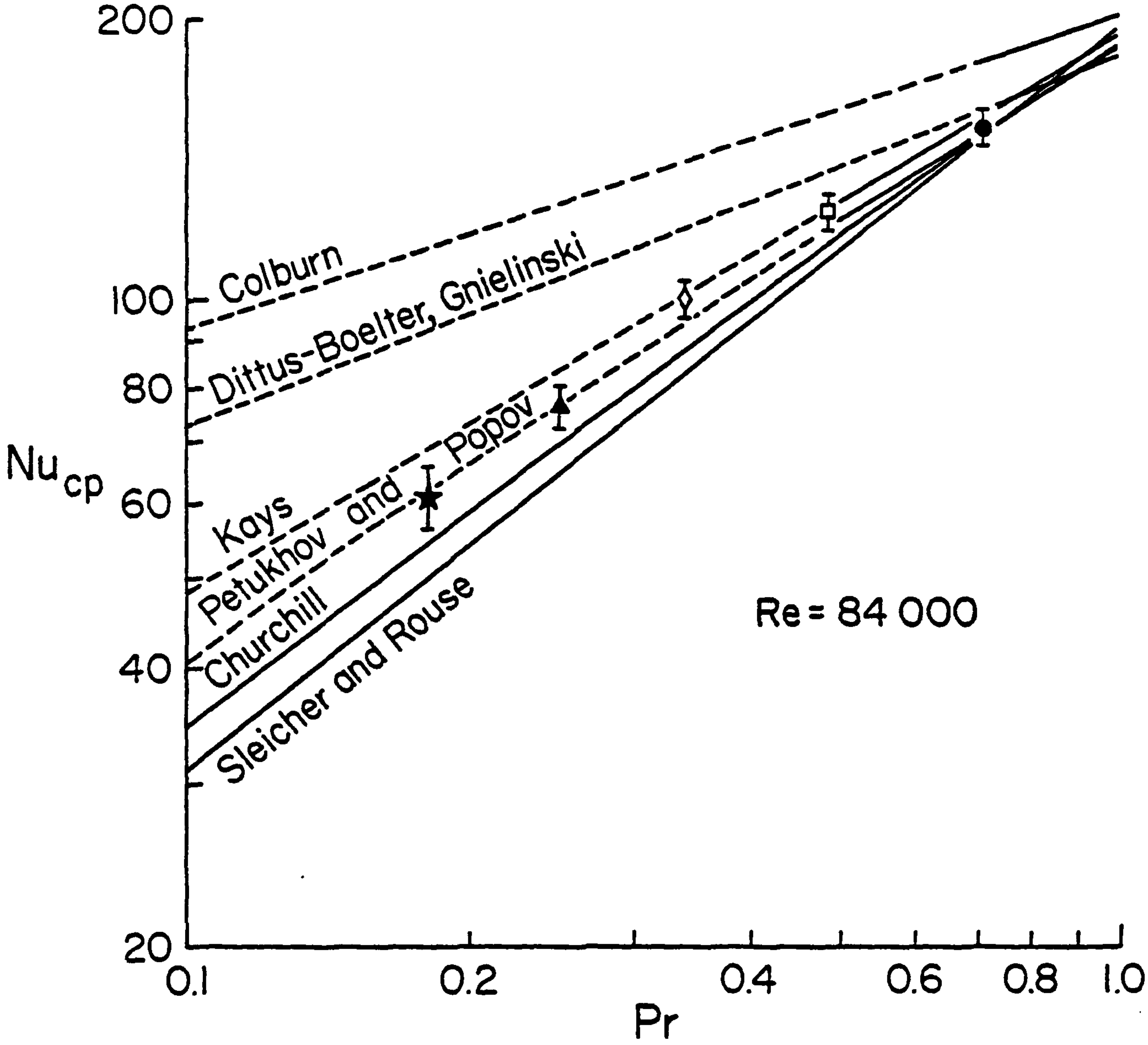

Figure 6c. Comparison between measured Nusselt number and Nusselt number predicted by correlations proposed by other investigators for constant properties.

There could be concern about the possibility of thermo-diffusion at high temperatures with the high ratios of molecular weights of the gases used in the binary mixtures. However, any effect of thermo-diffusion should reduce to zero as the data are extrapolated to a $T_w/T_b = 1$.

Heating with Property Variation

If power densities are to be increased, or the weight of systems such as the closed cycle gas turbine reduced, moderately high heating rates must be employed. Then, the temperature-dependence of the fluid transport properties will cause significant variation in properties appearing in the correlation equations for both heat transfer and friction coefficients. The results and correlations based on the constant properties idealizations become invalid. In this section the proposed modifications accounting for property variations are examined.

Since pressure taps were installed only near the entrance and exit of the test section, local friction factors could not be determined in this investigation. Overall average friction factors with heat addition were compared to the correlation proposed by Taylor [1967]

$$f_{av} = (0.0014 + 0.125 Re_w^{-0.32})(T_{w,\,av}/T_{b,av})^{-0.5} \qquad (10)$$

for the data of a wide variety of experiments with gas flow with $0.62 \lesssim Pr \lesssim 0.81$. Most previous measurements agreed within 10%. For

evaluation of this expression, integrated averages of both the local wall and local bulk gas temperature were used along with the average pressure to determine average density and viscosity. The overall friction factor was determined from the frictional pressure drop,

$$\Delta p_{fr} = p_1 - p_2 - \frac{G^2 R}{g_c}\left(\frac{T_{b_2}}{p_2} - \frac{T_{b_1}}{p_1}\right) \tag{11}$$

and the modified wall Reynolds number was defined as

$$Re_w = (GD/\mu_w)(T_{b,av}/T_{w,av}) \tag{12}$$

In the present study correlation (10) predicted most of the data within 5%. These measurements are presented in Figure 7. The few data deviating more than -5% from the correlation were mixture runs with maximum wall temperatures in excess of 668°C (1234°F) and $T_w/T_b > 1.8$ and with modified wall Reynolds numbers in the low range between 8,000 and 20,000. The data deviating more than +5% were all air runs with modified wall Reynolds numbers between 8,500 and 17,500. There appeared to be no effect of Prandtl number.

Experimental local Nusselt numbers were compared to Nusselt numbers predicted by modified forms of the prediction equations recommended by Pickett, Taylor and McEligot [1979]

$$Nu_b = 0.021\ Re_b^{0.8}\ Pr_b^{0.55}[(T_w/T_b)^{0.4} + 0.85\ D/x] \tag{13}$$

and by Taylor [1968]

$$Nu_b = 0.023\ Re_b^{0.8}\ Pr_b^{0.4}\ (T_w/T_b)^{-a} \tag{14}$$

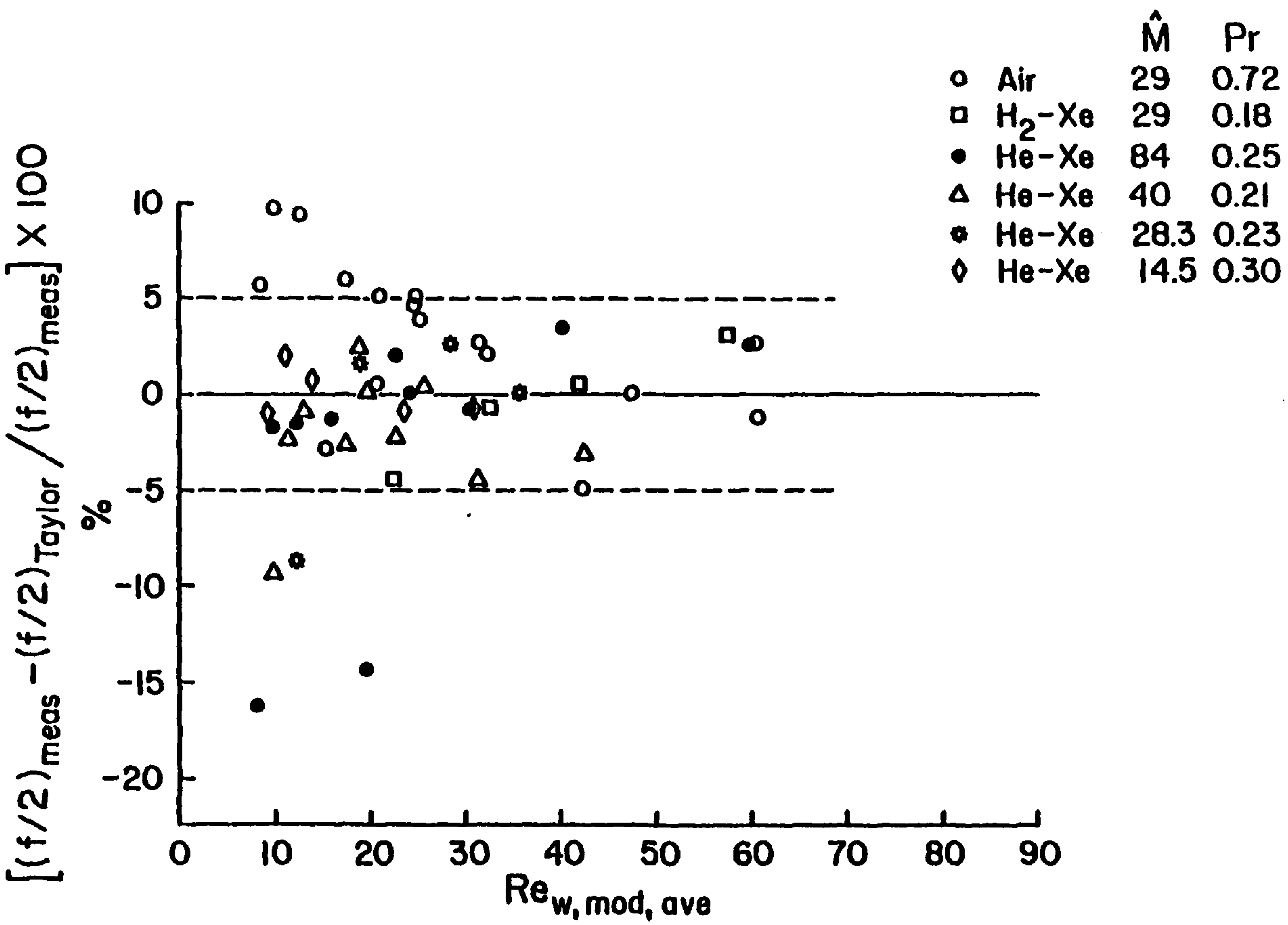

Figure 7. Comparison of average friction factors to Taylor [1967] correlation for variable gas properties.

where $a = (0.57 - \frac{1.59}{x/D})$

For the present comparisons a value of 0.65 was finally taken as the exponent of the Prandtl number in both of these equations.

Figure 8 shows the ratios of the measured Nusselt number to the Nusselt number predicted from Equation (13) and (14) as functions of x/D for two heating rates of air, He - Xe ($\tilde{M}$ = 14.5, Pr = 0.30) and H_2 - Xe($\tilde{M}$ = 29, Pr = 0.18). The data shown here are typical of all the data measured in this investigation. Both of the correlation equations appear to predict downstream Nusselt numbers with acceptable accuracy for all three Prandtl numbers. Both equations predict entrance effects better for the low heating rate than for the higher rate and are in close agreement with each other, even though the methods of handling entrance effects are different. A better understanding of entrance effects is needed.

Increasing the exponent of the Prandtl number to 0.65 yielded considerable improvement and promise in the predictions using Equations (13) and (14) for all Prandtl numbers. The value of $Pr^{0.65}/Pr^{0.4}$ is 0.65 for Pr = 0.181, 0.74 for Pr = 0.30 and 0.92 for air; it is obvious that determining the correct exponent for Prandtl number is far more difficult for values of Prandtl number near 1 than in the lower Prandtl number cases, where the sensitivity of the Nusselt number to the Prandtl number exponent is much greater.

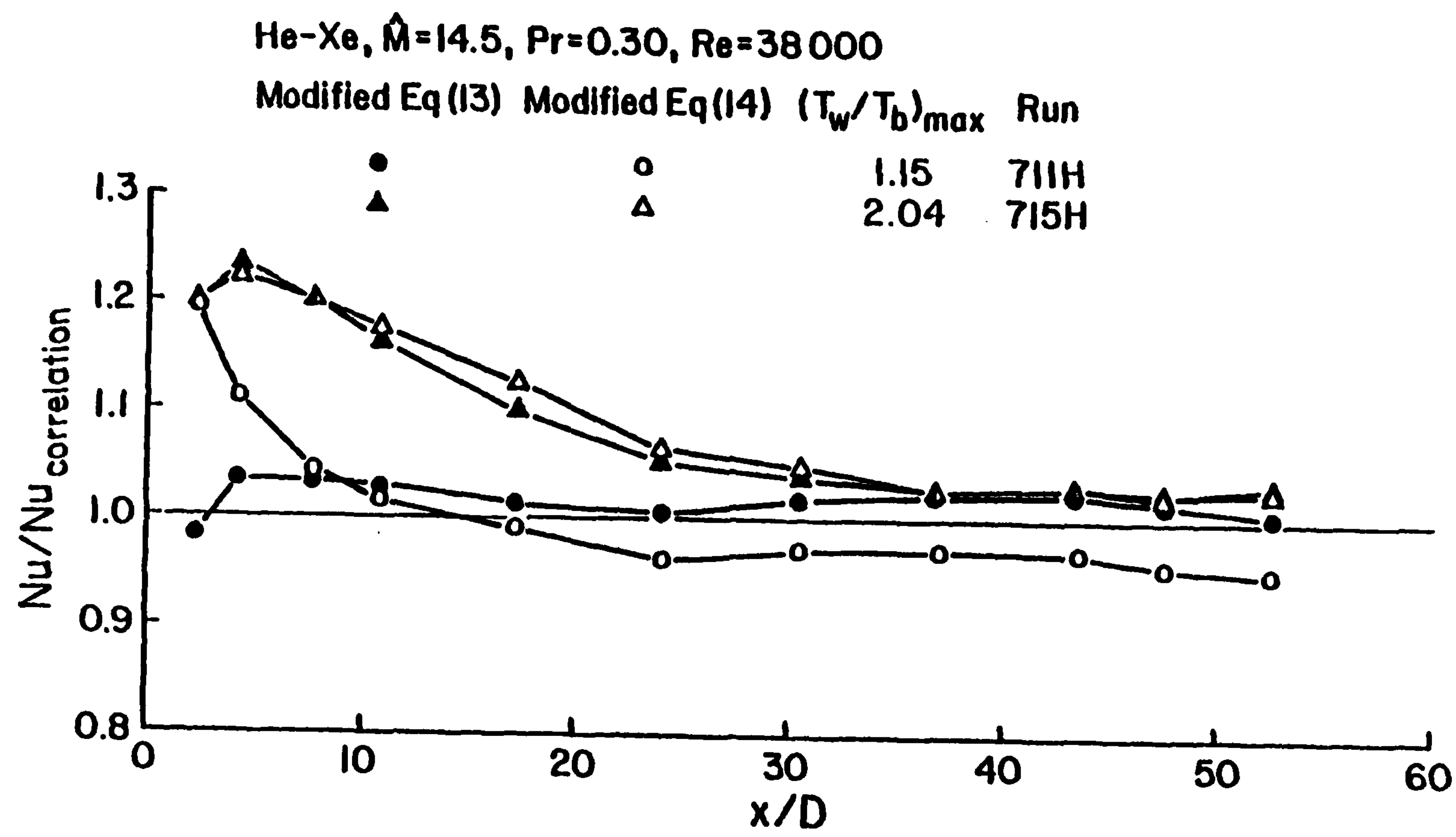

Figure 8a. Comparison to correlations for heat transfer with gas property variation.

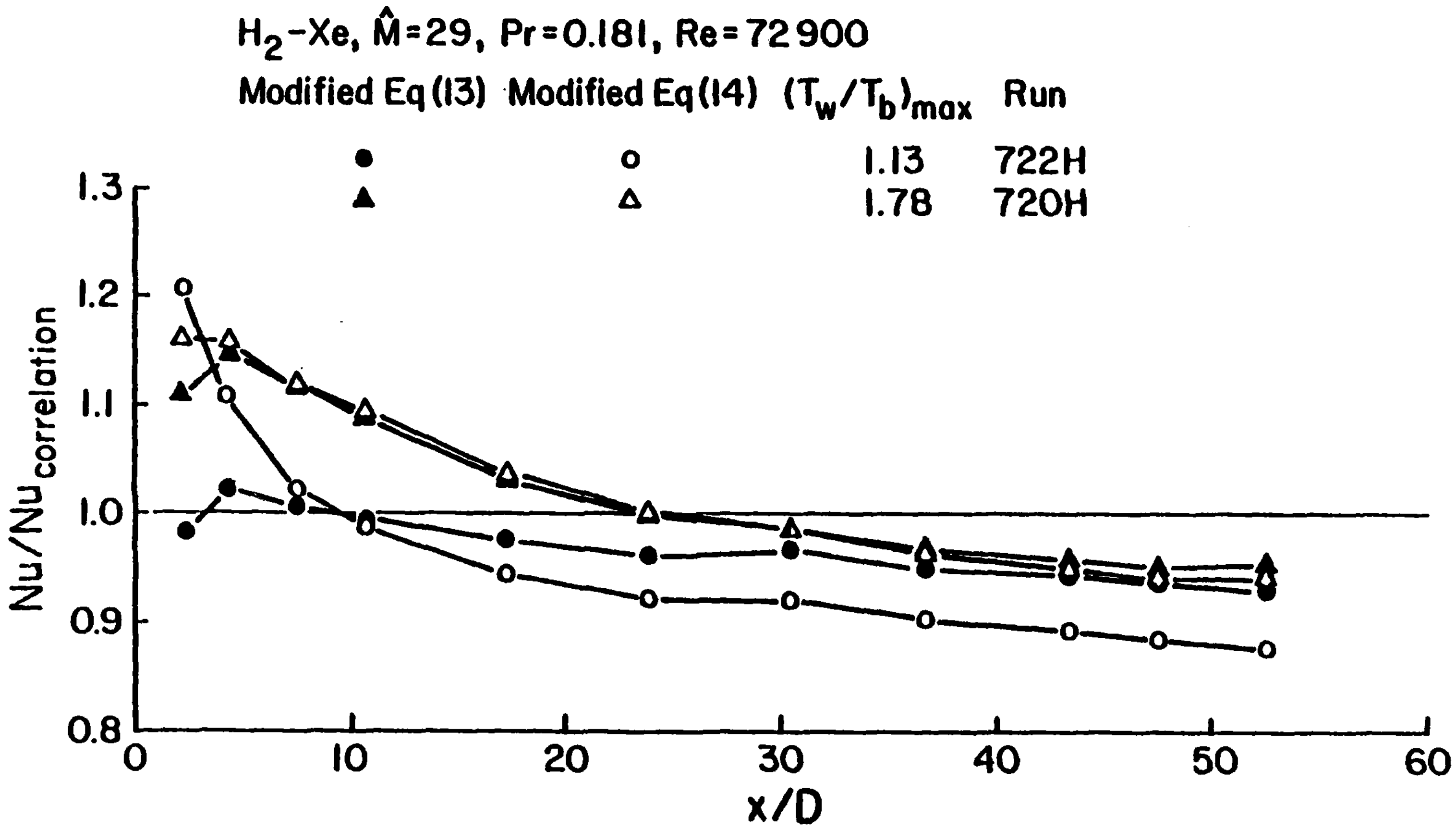

Figure 8b. Comparison to correlations for heat transfer with gas property variation.

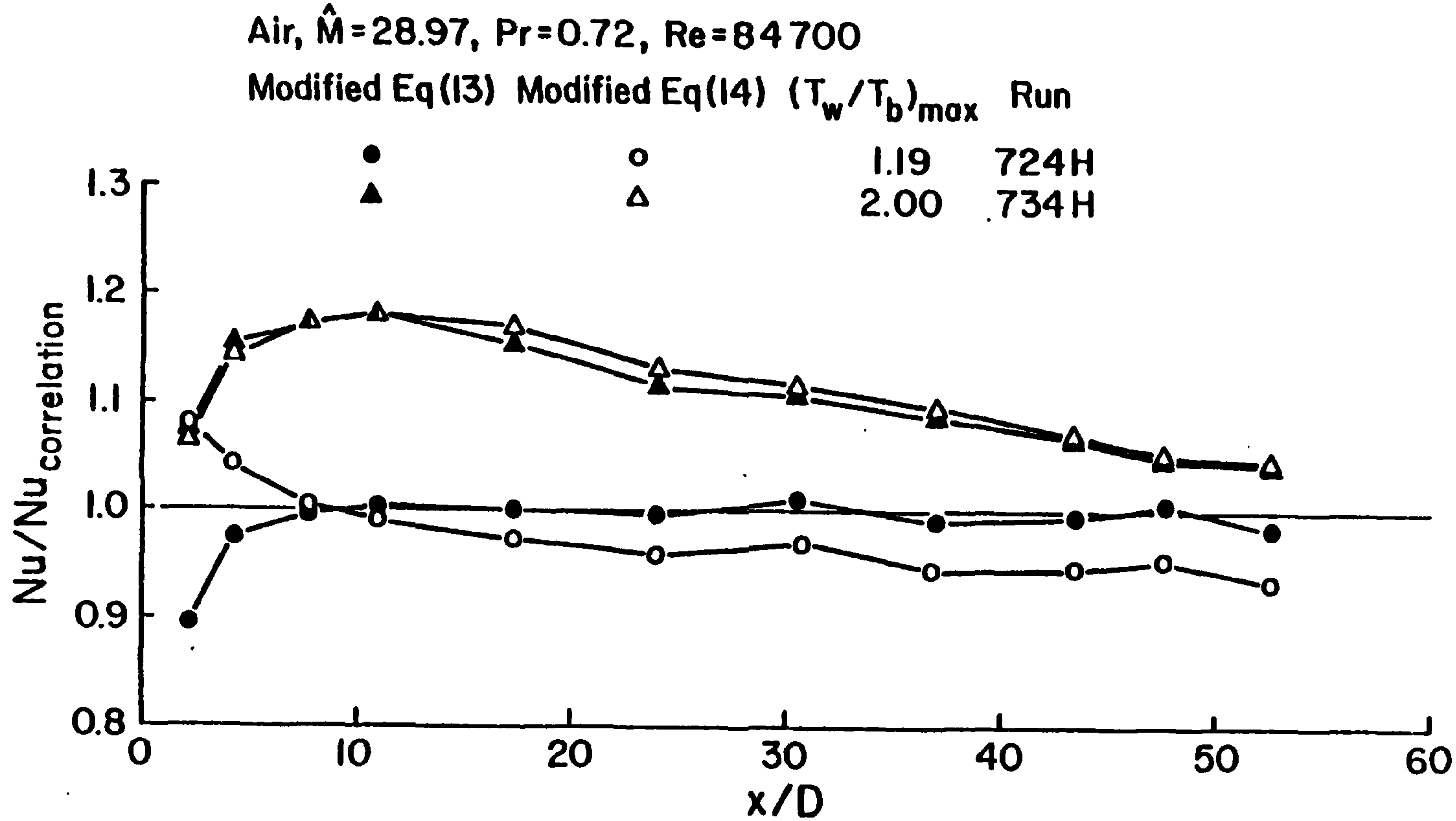

Figure 8c. Comparison to correlations for heat transfer with gas property variation.

Examination of air data with Reynolds numbers of $\simeq$ 34,000, 65,000 and 85,000 showed less than 3% variation of Nu/Nu_b with Reynolds number for a particular heating rate for all x/D greater than 2.2. The same held true for the gas mixtures when two Reynolds numbers were available for comparison at the same mixture concentration.

CONCLUSION

From experiments with heated flow of helium-xenon and hydrogen-xenon mixtures with Prandtl numbers in the range 0.18 to 0.30, the following major conclusions may be drawn. The Colburn analogy and the Dittus-Boelter correlation based on measurements for Pr $\gtrsim$ C.7, greatly overpredict Nusselt numbers for fully established conditions with constant properties in this range. The correlation equation of Sleicher and Rouse and also that of Churchill underpredict the Nusselt number in this range. Of the correlations examined, that of Petukhov [1970] best represents the data the constant property Nusselt number at 0.18 $\lesssim$ Pr $\lesssim$ 0.72 in fully established conditions.

The friction coefficients for flow with property variation were predicted within $\pm$5% by the correlation proposed by Taylor [1967], Equation (10), for modified wall Reynolds numbers greater than 20,000.

Nusselt numbers for flow with property variation were predicted using the correlation recommended by Pickett, Taylor and McEligot [1979], Equation (13), and Taylor [1968], Equation (14), but with the exponent of Prandtl number increased 0.65 in both cases. The predictions of both

correlations are in good agreement with each other. For low heating rates the measured and predicted values agreed within $\pm 10\%$ for axial distances from 4.3 to 52.3 diameters. For the higher heating rates both equations failed to predict the effects of the entrance region adequately at x/D less than about 20. Most of the data at x/D greater than 20 was predicted within $\pm 10\%$.

ACKNOWLEDGEMENTS

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APPENDICES

APPENDIX A

Uncertainty Analysis

To determine the validity of the deduced results it is necessary to determine their estimated experimental uncertainties. An analysis has been conducted in accordance with recognized procedures to estimate the percent uncertainty in the important heat transfer and friction characteristics along the test section. Doebelin [1966] considers the problem of computing a quantity N, where N is a known function of the n independent variables, $u_1, u_2, u_3, \ldots, u_n$. That is,

$$N = fn\ (u_1, u_2, u_3, \ldots, u_n) \tag{A1}$$

The u's are the measured quantities (instrument or component outputs) and are uncertain by $\pm\Delta u_1$, $\pm\Delta u_2$, $\pm\Delta u_3$, . . . , $\pm\Delta u_n$, respectively. These uncertainties will cause an uncertainty ΔN in the computed result N. We are concerned with experimental uncertainties here rather than systematic errors, like the thermocouple conduction error which can be corrected. The u's may be considered as absolute limits on the uncertainties, as statistical bounds such as 3σ limits, or as uncertainties on which we are willing to give certain odds as including the actual error. However, the method of computing ΔN and the interpretation of its meaning are different for the first case as compared with the second and third. After calculating the limits on the uncertainty in N, then $N \pm \Delta N$ and the

percentage uncertainly is known. In all cases, systematic errors (bias) were removed by calibration where they were known to exist.

If the individual errors are thought of as $\pm 3\sigma$ limits, then, as shown by Kline and McClintock [1953], the general equation used is

$$\Delta N = E_{arss} = \sqrt{(\Delta u_1 \frac{\partial f}{\partial u_1})^2 + (\Delta u_2 \frac{\partial f}{\partial u_2})^2 + \ . \ . \ . + (\Delta u_n \frac{\partial f}{\partial u_n})^2} \qquad \text{(A2)}$$

where E_{arss} represents a $\pm 3\sigma$ limit on N and 99.7 percent of the values of N can be expected to fall within these limits (arss = absolute root-sum square).

An analysis was performed to determine the uncertainty of local bulk Nusselt number, Nu, as calculated from the measured experimental data. Table A1 lists the uncertainties of the instruments (Δu's) used in this investigation. The uncertainties of the directly measured quantities were determined from manufacturers' specifications and experience. The uncertainties of the gas properties were not included.

The estimated uncertainty in the experimental Nusselt number which results from the uncertainty in a measured variable is shown in Table A2. The measured variables included mass flow rate, current, inlet bulk temperature of the gas, wall temperature, inlet static pressure, and the resistance per unit length of the test section. Uncertainties, Δu, in these measurements were assigned from Table A1 and their values are shown in Table A2. An uncertainty in mass flow rate of 1.5 percent was used in Table A2. The values of $\partial Nu/\partial u$ in Table A2 were attained by changing the variable by an amount equal to its estimated uncertainty and rerunning the

Table A1. Uncertainties of Measured Values

Measured Quantity	Instrument	Uncertainty (Based on Manufacturer's Specification Unless Otherwise Stated)	Notes
Current	Weston Ammeter Model 370 No. 13605	0.0 to 2.0 amp range, ±0.17% of full scale 2.0 to 5.0 amp range, ±0.25% of full scale	
Voltage	Fluke Voltmeter Model 883AB	±0.1% of input voltage	Voltmeter used as a check on test section voltage
Mass Flow Rate	Calibrated tubular flow meter	±1.5% of flow rate measured with positive displacement meter	Tubing for test section and flow meter from same manufacturer shipment
Wall and Inlet Bulk Temperature	Keithley Model 179 Digital Multimeter	±0.004% of reading (200mV range = 0.014mV)	
	Premium Grade Chromel - Alumel Thermocouples	±2 F, 3/8% of reading above 553K (535F)	For relative measurements, uncertainty can be considered better as same spool of wire was used
Thermocouple Location Pressure Tap Location	Gaertner Cathetometer	±0.1% of distance from datum	(Estimate of uncertainty)

Table A1. Uncertainties of Measured Values (continued)

Measured Quantity	Instrument	Uncertainty (Based on Manufacturer's Specification Unless Otherwise Stated)	Notes
Test section I.D. and O.D.	Starret Micrometer and small hole gage	±0.001 inch	Uncertaintv based on calibrated tubular flow meter uncertainty
Static Pressure	Heise bourdon tube gage	±0.15 psia	
	Kulite XT-140-100G Pressure Transducer	±0.1% of full scale (100 psig)	
Atmospheric Pressure	Welch Mercury Barometer	±0.05 psia (±0.03 in Hg)	(Estimate of uncertainty)
Pressure Drop	MKS Baratron Pressure Meter	Accuracy of ±0.02% of full range plus 0.15% of dial reading. Repeatability of ±.005 to 0.02% of full range (Full range = 1000 mmHg)	

Table A2. Percentage Uncertainties in the Measured Nusselt Number.

	x/d	Variable, u								E_{arss}	% Uncertainty
		m		I		T_b, in		T_w			
		$\frac{\partial Nu}{\partial}$	Δu	$\frac{\partial Nu}{\partial u}$	Δu	$\frac{\partial Nu}{\partial u}$	Δu	$\frac{\partial Nu}{\partial u}$	Δu		
Run 704 He-Xe $\hat{M} \approx 40$	1.3	0.04	1.5%	0.58	0.25% of full scale	2.13	2.0°F	2.28	2.0°F	6.240	8.14
	2.2	.05	$0.83 \frac{lbm}{hr}$	.54	0.25 amp	1.77		1.93		5.239	7.45
	4.3	.08		.50		1.38		1.53		4.123	6.60
Re_{in} = 59900	10.9	.14		.47		1.06		1.20		3.207	5.86
$\left(\frac{T_w}{T_b}\right)_{max} = 1.17$	23.9	.25		.50		.91		1.04		2.774	5.55
	43.6	.45		.58		.87		.98		2.65	5.61
	52.6	.52		.61		.83		.95		2.564	5.58
Run 701 He-Xe	1.3	0.02	1.5%	0.63	0.25% of full scale	0.22	2.0°F	0.44	2.0°F	1.033	1.40
$\tilde{M} \approx 40$	2.2	.02	$0.81 \frac{lbm}{hr}$	.57	0.5 amp	.16		.35	2.0	.821	1.24
	4.3	.03		.48		.10		.28	2.2	.691	1.22
Re_{in} = 58900	10.9	.05		.40		.07		.24	2.6	.671	1.48
	23.9	.08		.36		.06		.23	3.2	.770	2.13
$\left(\frac{T_w}{T_b}\right)_{max} = 1.83$	43.6	.18		.40		.07		.25	3.7	.968	3.07
	52.6	.23		.41		.07		.28	3.9	1.135	3.77

Table A2. Percentage Uncertainties in the Measured Nusselt Number (continued)

	x/D	Variable, u								E_{arss}	% Uncertainty
		m		I		T_b in		T_w			
		$\frac{\partial Nu}{\partial u}$	Δu	$\frac{\partial Nu}{\partial u}$	Δu	$\frac{\partial Nu}{\partial u}$	Δu	$\frac{\partial Nu}{\partial u}$	Δu		
Run 722 H_2-Xe $\tilde{M}$ ~ 29.0	1.3	0.05	1.5%	0.48	0.25% of full scale	2.99	2.0°F	3.05	2.0°F	8.54	11.21
Re_{in}=73800	2.2	.06	0.84 $\frac{lbm}{hr}$	.43	0.25 amp	2.60		2.68		7.49	10.49
$\frac{T_w}{T_b}$ max = 1.13	4.3	.09		.36		2.02		2.13		5.87	9.26
	10.9	.16		.30		1.51		1.63		4.45	8.09
	23.9	.29		.27		1.27		1.39		3.77	7.55
	43.6	.48		.26		1.16		1.27		3.46	7.39
	52.6	.55		.29		1.11		1.22		3.33	7.32
Run 720 H_2-Xe	1.3	0.01	1.5%	0.64	0.25% of full scale	0.21	2.0°F	0.36	2.0°F	0.797	1.10
	2.2	.01		.61		.15		.32	2.0	.770	1.18
$\tilde{M}$ ~29.0	4.3	.02		.55		.09		.28	2.1	.674	1.21
Re_{in}=71200	10.9	.04	0.82 $\frac{lbm}{hr}$	.53	0.5 amp	.05		.23	2.6	.663	1.48
$\frac{T_w}{T_b}$ = 1.78	23.9	.05		.55		.05		.22	3.1	.743	2.06
	43.6	.13		.61		.05		.23	3.7	.916	2.95
	52.6	.18		.64		.06		.24	3.9	1.007	3.37

Table A2. Percentage Uncertainties in the Measured Nusselt Number (continued)

	x/D	Variable, u: $\dot{m}$ $\frac{\partial Nu}{\partial u}$	$\dot{m}$ Δu	I $\frac{\partial Nu}{\partial u}$	I Δu	T_b in $\frac{\partial Nu}{\partial u}$	T_b in Δu	T_n $\frac{\partial Nu}{\partial u}$	T_n Δu	E_{arss}	% Uncertainty
Run 727 H Air	1.3	0.02	1.5%	1.37	0.25% of full scale	3.11	2.0°F	3.53	2.0°F	9.415	6.35
	2.2	.04		1.30		2.77		3.19		8.456	5.96
Re_{in} = 66100	4.3	.07		1.22		2.33		2.73		7.185	5.49
	10.9	.16	0.68 $\frac{lbm}{hr}$	1.16	0.25 amp	1.92		2.31		6.015	5.05
	23.9	.32		1.19		1.71		2.07		5.382	4.84
$\frac{T_w}{T_b}$ = 1.20	43.6	.54		1.29		1.60		1.93		5.038	4.77
	52.6	.62		1.31		1.54		1.86		4.859	4.74
Run 738H Air	1.3	0.00	1.5	0.99	0.25% of full scale	0.01	2.0°F	0.66	2.8°F	1.913	1.32
	2.2	.01	0.66 $\frac{lbm}{hr}$	.89	0.5 amp	.05		.60	3.1	1.915	1.44
Re_{in} = 64200	4.3	.02		.78		.06		.53	3.5	1.899	1.62
$\frac{T_w}{T_b}{}_{max}$ = 2.38	10.9	.01		.68		.02		.49	3.9	1.941	1.93
	23.9	.01		.60		.01		.50	4.4	2.220	2.70
	43.6	.16		.63		.06		.56	4.7	2.656	3.57
	52.6	.23		.65		.05		.59	4.9	2.915	4.06

computer program for data reduction at the experimental conditions. It was found that a change of 0.2 psia to the inlet static pressure did not change the experimental Nusselt number noticeably. Also, an uncertainty of 0.00008 Ω/in in the measurement of resistance per unit length had an insignificant effect on the percentage uncertainty in the experimental Nusselt number.

Three types of comparisons can be made from Table A2. A comparison between the two runs shows that the percentage uncertainty for a relatively low heating rate run to be higher than a high heating rate run at about the same Reynolds number. The result is due to the relatively high percentage uncertainties in the inlet bulk and wall temperatures being much more dominant in the lower heating rate case. Secondly, the change in the percentage uncertainty along the axial length of the test section can be examined. For the low heating rates the major uncertainties in the Nusselt number are provided by the inlet bulk gas temperature and the wall temperatures; they decrease with x/D. For higher heating rates, the uncertainty increases with x/D because the uncertainties in tube wall temperature and, therefore, temperature difference increase significantly with temperature level, while the contributions of uncertainties in mass flow rate, electrical power and inlet gas temperature remain small. Thirdly, the individual variables can be compared to each other for the two different heating rates as well as for the range of x/D.

APPENDIX B

EXPERIMENTAL DATA WITH HEAT ADDITION

Table B1. Summary of Experimental Data

Run	Gas	M	Pr_i	Re_i	$(T_w/T_b)_{max}$	q^+_{max}
686H	He-Xe	83.8	0.25	85147	1.18	0.0007
687H				85802	1.42	.0016
688H				86740	1.65	.0026
689H				87373	1.89	.0035
690H				86063	2.17	.0049
691H				32646	1.16	.0009
692H				32647	1.39	.0022
693H				33513	1.62	.0034
694H				33328	1.88	.0051
695H				33947	2.22	.0069
696H	He-Xe	40.0	0.21	36183	1.99	.0053
697H				34994	1.75	.0041
698H				34280	1.59	.0032
699H				34686	1.36	.0018
700H				34865	1.15	.0007
701H				58657	1.83	.0039
702H				58525	1.59	.0027
703H				61534	1.38	.0017
704H				59851	1.17	.0008
705H				61772	1.77	.0037
707H	He-Xe	28.3	0.23	53390	1.67	.0030
708H				55449	1.38	.0017
709H				48411	2.06	.0051
710H				49001	1.16	.0007
711H	He-Xe	14.5	0.30	40869	1.15	.0006
712H				40554	1.32	.0013
713H				35374	1.61	.0027
714H				38962	1.84	.0034
715H				34042	2.04	.0047
719H	H_2-Xe	29.0	0.18	73916	1.48	0.0021
720H				71174	1.78	.0034
721H				72531	1.30	.0013
722H				73803	1.13	.0005

Table B1. Summary of Experimental Data
(continued)

Run	Gas	M	Pr_i	Re_i	$(T_w/T_b)_{max}$	q^+_{max}
723H	Air	28.97	0.72	84169	1.20	.0005
724H				84455	1.19	.0005
725H				84778	1.46	.0012
726H				64990	1.40	.0012
727H				66076	1.19	.0005
728H				34149	1.74	.0023
729H				34946	1.45	.0014
730H				34765	1.20	.0006
731H				33882	2.03	.0033
732H				34777	2.35	.0044
733H				84294	1.74	.0019
734H				84742	2.00	.0026
735H				85824	2.30	.0033
736H				64311	1.90	.0024
737H				66215	1.73	.0019
738H				64199	2.38	.0038

The headings and their definitions used in the listing of the heated flow data are below.

Heading	Definition
TIN	Inlet gas temperature, °F
TOUT	Calculated outlet gas temperature, °F
I	Alternating current, amperes
E	Voltage drop between voltage taps, volts
PR,IN	Inlet Prandtl number, $c_p \mu/k$
GR/RESQ	Ratio of Grashof number $g D^4 q''_w/(\nu^2 kT)_i$ to the square of the inlet Reynolds number, GD/μ_i
MACH (2)	Mach number at thermocouple 2
MACH (16)	Mach number at thermocouple 16

Heading	Definition
TSURR	Temperature of surroundings inside draft shield, °F
Q+(8)	Nondimensional turbulent heat flux parameter. Corresponds to q^+ in text at thermocouple 8, $q^+ = q''_w/(G\ c_{p,i}\ T_i)$
TC	Thermocouple number
X/D	Axial position, corresponds to x/D in text
HL/QGAS	Ratio of heat loss to heat flux to gas
TW	Inside tube wall temperature, °F
TW/TB	Wall to bulk temperature ratio
QGAS	Heat flux to gas, Btu/hr-ft^2
HTCOEF	Heat transfer coefficient, Btu/hr-ft^2-°F
BULK REYNOLDS	Reynolds number evaluated at bulk temperature, GD/μ_b
BULK NUSSELT	Nusselt number evaluated at bulk temperature, hD/k_b
PT	Pressure tap: 1-near inlet, 2-near outlet
TB	Bulk static temperature °F
PRESS DEFECT	Pressure defect, $\rho_i\ g_c\ (p_i - p)/G^2$
TW,AV(F)	Average inside tube wall temperature °F
TB,AV(F)	Average bulk gas temperature °F
TW,AV/TB,AV	Average wall to average bulk temperature ratio
DELTA P(PSI)	Pressure drop from start of heating to pressure tap #2
RE,B,AV	Average value of bulk Reynolds number from start of heating to pressure tap #2, $GD/\mu_{b,av}$
RE,W,MOD,AV	Average value of modified wall Reynolds number, $GD/\mu_{w,av}\ (T_{b,av}/T_{w,av})$
F,B,AV	Friction factor through heated section of tube, $g_c \rho_{b,av}\ D\ p_{fr}/2LG^2$

RUN 686H, DATE 4/20/81, GAS HE XE, MOLECULAR WT. = 83.80
TIN = 73.7 F, TOUT = 153.8 F, MASS FLOW RATE = 74.8 LB/HR, I = 42.5 AMPS, E = 2.782 VOLTS
PR,IN = .251, GR/RESQ = .167E-02, MACH(2) = .098, MACH(16) = .105, T,SURR = 83.0 F, Q+(8) = .000073

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.165	107.6	1.067	6731.2	194.61	85147.	273.60
3	.3	.692	119.5	1.089	3322.6	71.88	85103.	161.03
4	.5	.188	128.3	1.105	4737.4	66.46	85053.	121.47
5	.8	.094	134.6	1.116	5144.7	84.72	84999.	110.90
6	1.3	.056	143.1	1.130	5335.3	77.91	84883.	109.29
7	2.2	.038	151.5	1.144	5431.9	71.75	84697.	100.47
8	4.3	.033	163.5	1.159	5461.1	64.54	84223.	89.97
9	7.6	.035	174.6	1.170	5456.3	60.00	83512.	83.65
10	10.8	.037	182.5	1.175	5447.8	57.76	82844.	79.42
11	17.3	.042	196.5	1.180	5424.8	54.77	81510.	74.29
12	23.8	.049	207.0	1.180	5393.2	53.72	80247.	71.91
13	30.4	.053	216.3	1.177	5379.4	53.60	79014.	70.63
14	37.0	.057	226.7	1.176	5360.8	52.79	77824.	68.67
15	43.5	.061	235.8	1.174	5346.8	52.69	76686.	67.90
16	47.9	.064	242.6	1.173	5334.8	52.30	75931.	66.64
17	52.3	.067	249.4	1.172	5321.4	51.83	75206.	65.70
18	56.5	.144	254.9	1.170	4962.8	48.43	74551.	60.94
19	58.5	1.008	244.6	1.149	2826.8	31.37	74317.	39.30
20	59.1	-.113	210.7	1.093	6362.9	115.10	74251.	144.25

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	68.5	1.00	72.0	-.550E-01
2	54.0	67.7	1.17	147.8	.718E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
197.5	103.8	1.17	.786E+00	80034.	59405.	.00486

RUN 687H, DATE 4/20/81, GAS HE XE, MOLECULAR WT. = 63.60
TIN = 72.8 F, TOUT = 265.0 F, MASS FLOW RATE = 75.3 LB/HR, I = 65.5 AMPS, E = 4.327 VOLTS
PR,IN = .251, GR/RESQ = .404E-02, MACH(2) = .097, MACH(16) = .111, T,SURR = 98.0 F, Q+(8) = .001602

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COFF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.171	155.8	1.160	16160.5	192.95	85802.	271.74
3	.3	.725	183.8	1.211	7778.8	70.01	85695.	93.52
4	.5	.164	204.5	1.249	11549.6	88.05	85576.	123.80
5	.8	.106	220.1	1.276	12169.0	83.39	85445.	117.13
6	1.3	.053	241.3	1.312	12738.6	76.98	85169.	107.66
7	2.2	.041	263.5	1.346	12969.0	70.15	84726.	97.90
8	4.3	.036	295.8	1.387	13060.6	62.26	83620.	85.95
9	7.6	.038	324.2	1.410	13060.2	57.58	81966.	78.19
10	10.8	.041	343.5	1.417	13044.2	55.43	80465.	74.12
11	17.4	.048	377.6	1.422	12986.1	52.52	77574.	68.11
12	23.6	.056	404.7	1.416	12912.9	51.17	74939.	64.47
13	30.4	.063	427.8	1.403	12858.1	50.77	72479.	62.16
14	37.0	.069	449.6	1.389	12797.8	50.58	70213.	60.39
15	43.5	.076	469.6	1.374	12736.0	50.69	68136.	59.92
16	48.0	.081	483.6	1.365	12691.5	50.67	66794.	57.91
17	52.4	.066	498.1	1.358	12639.0	50.48	65536.	56.77
18	56.6	.202	512.1	1.352	11433.9	45.51	64447.	50.46
19	58.6	1.268	482.2	1.302	6046.0	27.91	64068.	30.76
20	59.2	.083	447.6	1.252	12634.0	69.98	63967.	77.04

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	69.6	1.00	71.1	-.550E-01
2	54.1	68.5	1.36	251.7	.980E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
379.4	144.7	1.39	.107E+01	75436.	40356.	.00493

RUN 688H, DATE 4/20/81, GAS HE XE, MOLECULAR WT. = 83.60
TIN = 72.8 F, TOUT = 375.3 F, MASS FLOW RATE = 76.2 LB/HR, I = 82.9 AMPS, E = 5.503 VOLTS
PR,IN = .251, GR/RESQ = .661E-02, MACH(2) = .096, MACH(16) = .116, T,SURR = 121.0 F, Q+(8) = .002555

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.180	205.8	1.254	26256.8	196.26	86740.	276.51
3	.3	.785	251.8	1.338	12105.9	67.69	86567.	95.27
4	.5	.178	285.4	1.399	18387.2	87.01	86373.	122.29
5	.8	.107	309.9	1.441	19606.3	83.57	86166.	117.26
6	1.3	.062	344.4	1.498	20480.5	76.90	85726.	107.48
7	2.2	.043	380.3	1.552	20906.2	70.22	85018.	97.51
8	4.3	.039	433.2	1.615	21074.8	62.17	83266.	84.89
9	7.7	.043	480.9	1.648	21059.9	57.15	80717.	76.00
10	10.8	.048	512.9	1.654	21017.4	54.85	78440.	71.27
11	17.4	.058	566.4	1.646	20885.2	52.07	74221.	64.59
12	23.9	.076	610.5	1.626	20575.0	50.12	70570.	59.60
13	30.5	.089	643.7	1.592	20404.6	49.93	67286.	57.02
14	37.1	.103	676.5	1.562	20199.4	49.66	64371.	54.61
15	43.6	.116	704.4	1.530	20009.0	49.92	61792.	53.02
16	48.1	.127	725.4	1.512	19839.3	49.76	60172.	51.64
17	52.5	.135	742.0	1.490	19714.8	50.19	58086.	50.97
18	56.6	.274	761.8	1.476	17590.4	44.84	57410.	44.70
19	58.7	3.123	713.6	1.409	5417.1	16.03	57074.	15.88
20	59.3	-.117	587.7	1.254	25066.1	119.55	56990.	118.07

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	70.9	1.00	71.1	-.548E-01
2	54.2	69.6	1.48	355.7	.120E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
567.2	187.3	1.59	.131E+01	72450.	30434.	.00473

RUN 689H, DATE 4/20/81, GAS HE XE, MOLECULAR WT. = 83.80
TIN = 72.3 F, TOUT = 467.5 F, MASS FLOW RATE = 76.7 LB/HR, I = 96.4 AMPS, E = 6.490 VOLTS
PR,IN = .251, GR/RESQ = .891E-02, MACH(2) = .096, MACH(16) = .123, T,SURR = 150.0 F, Q+(8) = .003449

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.191	259.3	1.356	36142.1	192.51	87373.	271.53
3	.3	.804	321.0	1.469	16279.6	65.58	87136.	92.37
4	.5	.166	366.5	1.550	25281.1	86.52	86878.	121.64
5	.8	.120	400.9	1.610	26384.3	81.19	86591.	113.89
6	1.3	.064	448.9	1.668	27648.6	75.41	85992.	105.24
7	2.2	.049	501.0	1.765	28373.2	68.35	85035.	94.53
8	4.3	.046	578.4	1.854	28609.7	60.00	82695.	81.15
9	7.7	.053	645.8	1.891	28548.2	54.93	79360.	71.62
10	10.9	.060	689.1	1.890	28450.7	52.74	76454.	66.84
11	17.4	.077	763.0	1.866	28144.9	49.75	71235.	59.43
12	23.9	.120	823.3	1.829	27180.4	46.89	66896.	53.12
13	30.5	.141	866.5	1.775	26744.6	46.35	63170.	50.02
14	37.1	.168	909.6	1.729	26221.9	45.59	59960.	47.04
15	43.7	.191	944.1	1.681	25766.7	45.55	57184.	45.11
16	48.1	.212	970.5	1.654	25364.8	45.08	55486.	43.51
17	52.5	.229	990.8	1.625	25058.4	45.19	53958.	42.57
18	56.8	.393	1012.7	1.603	22139.0	40.19	52671.	37.06
19	58.8	*****	941.1	1.515	1128.0	2.36	52408.	2.19
20	59.4	-.121	772.0	1.328	34491.0	114.55	52350.	104.69

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	71.4	1.00	70.7	-.548E-01
2	54.3	69.8	1.61	444.7	.142E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
761.5	225.5	1.78	.156E+01	70411.	24136.	.00476

RUN 690H, DATE 4/20/81, GAS HE XE, MOLECULAR WT. = 83.80
TIN = 73.2 F, TOUT = 613.0 F, MASS FLOW RATE = 75.7 LB/HR, I = 113.2 AMPS, E = 7.069 VOLTS
PR,IN = .251, GR/RESQ = .144E-01, MACH(2) = .069, MACH(16) = .121, T,SURR = 204.0 F, Q+(3) = .004845

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.197	335.0	1.496	50496.7	192.33	86063.	271.01
3	.3	.780	415.9	1.643	22914.8	67.07	85735.	94.31
4	.5	.157	476.4	1.749	35412.9	88.52	85376.	124.16
5	.8	.115	522.8	1.826	36854.8	83.00	84978.	116.04
6	1.3	.070	569.5	1.933	38595.1	76.35	84153.	105.96
7	2.2	.053	660.8	2.033	39418.4	69.37	82847.	95.11
8	4.3	.052	765.9	2.137	39742.5	61.04	79720.	81.14
9	7.7	.065	859.9	2.170	39524.1	55.64	75364.	70.62
10	10.9	.077	921.2	2.155	39245.5	53.13	71721.	64.70
11	17.4	.102	1014.3	2.084	38606.8	50.47	65442.	56.90
12	24.0	.178	1081.1	1.999	36273.9	47.22	60547.	49.84
13	30.6	.208	1126.2	1.905	35477.5	47.25	56532.	47.00
14	37.2	.242	1169.3	1.825	34601.2	47.17	53198.	44.55
15	43.8	.270	1201.5	1.746	33905.0	47.96	50390.	43.16
16	48.3	.297	1228.1	1.704	33258.5	47.92	48701.	41.87
17	52.7	.317	1247.7	1.661	32767.6	48.52	47202.	41.25
18	56.9	.463	1270.2	1.628	29560.4	44.54	45935.	38.96
19	58.9	*****	1184.2	1.537	-3827.6	-6.71	45730.	-5.53
20	59.6	-.114	975.8	1.338	47873.4	133.38	45694.	109.60

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	76.2	1.00	71.8	-.550E-01
2	54.4	74.5	1.65	583.9	.163E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
996.5	286.3	1.95	.164E+01	86398.	19574.	.00416

RUN 691H, DATE 4/21/81, GAS HE XE, MOLECULAR WT. = 83.60
TIN = 70.5 F, TOUT = 169.4 F, MASS FLOW RATE = 26.6 LB/HR, I = 30.0 AMPS, E = 1.950 VOLTS
PR,IN = .251, GR/RESQ = .170E-02, MACH(2) = .066, MACH(16) = .071, T,SURR = 60.7 F, Q+(8) = .000052

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.260	98.3	1.054	3769.3	134.09	32646.	189.14
3	.3	2.174	108.5	1.073	879.0	23.13	32626.	32.61
4	.5	.269	116.5	1.087	2200.5	48.19	32607.	67.92
5	.8	.183	122.7	1.098	2361.4	45.81	32582.	64.53
6	1.3	.108	131.7	1.113	2523.3	42.32	32526.	59.53
7	2.2	.073	141.1	1.128	2607.1	38.56	32439.	54.16
8	4.3	.066	155.3	1.146	2626.8	33.71	32212.	47.05
9	7.6	.068	167.8	1.156	2622.7	31.09	31867.	43.01
10	10.8	.075	177.1	1.161	2608.0	29.65	31546.	40.67
11	17.3	.087	191.6	1.163	2583.6	28.45	30914.	38.38
12	23.6	.103	203.5	1.161	2546.5	27.90	30328.	37.03
13	30.4	.112	213.6	1.155	2529.4	28.15	29757.	36.76
14	37.0	.122	224.4	1.151	2508.2	28.08	29215.	36.11
15	43.5	.131	234.4	1.147	2490.1	28.26	28704.	35.82
16	47.9	.138	241.6	1.144	2474.9	28.23	28367.	35.40
17	52.3	.144	248.0	1.141	2463.2	28.45	28046.	35.34
18	56.5	.304	253.9	1.138	2067.8	24.04	27775.	29.61
19	58.5	*****	236.3	1.108	-97.5	-1.45	27721.	-1.79
20	59.1	-.277	195.9	1.042	3863.4	150.57	27697.	184.92

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	38.6	1.00	69.8	-.689E-01
2	54.0	38.4	1.14	163.7	.900E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
192.9	108.1	1.15	.254E+00	30286.	23118.	.00609

RUN 692H, DATE 4/21/81, GAS HE XE, MOLECULAR WT. = 83.80
TIN = 71.0 F, TOUT = 320.1 F, MASS FLOW RATE = 28.6 LB/HR, I = 47.6 AMPS, E = 3.122 VOLTS
PR,IN = .251, GR/RESQ = .434E-02, MACH(2) = .066, MACH(16) = .078, T,SURR = 94.0 F, Q+(8) = .002104

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.263	139.5	1.131	9589.4	139.23	32647.	196.33
3	.3	2.142	164.5	1.176	2252.1	24.19	32597.	34.07
4	.5	.274	184.5	1.212	5561.6	49.49	32549.	69.65
5	.8	.189	200.2	1.240	5988.6	46.94	32486.	65.97
6	1.3	.105	223.3	1.278	6430.8	43.46	32349.	60.88
7	2.2	.083	249.2	1.317	6576.4	38.67	32126.	53.67
8	4.3	.069	286.0	1.361	6680.2	33.89	31567.	46.55
9	7.6	.075	319.8	1.384	6657.8	30.88	30738.	41.48
10	10.8	.082	342.9	1.389	6625.2	29.56	30000.	38.90
11	17.4	.099	380.3	1.383	6545.2	28.23	28608.	35.71
12	23.8	.117	408.7	1.364	6452.7	27.90	27384.	34.01
13	30.4	.130	431.4	1.339	6387.9	28.41	26271.	33.43
14	37.0	.145	453.6	1.316	6313.2	28.93	25268.	32.93
15	43.5	.160	474.0	1.293	6240.2	29.65	24369.	32.73
16	48.0	.172	488.6	1.279	6180.8	30.02	23801.	32.47
17	52.4	.184	501.6	1.265	6126.7	30.57	23281.	32.45
18	56.6	.519	513.5	1.255	4778.2	24.31	22859.	25.40
19	58.6	*****	461.9	1.184	-1113.8	-7.82	22801.	-8.14
20	59.2	-.213	371.0	1.065	9134.7	183.37	22772.	190.55

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	38.9	1.00	70.2	-.689E-01
2	54.1	38.6	1.28	307.2	.125E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
379.5	166.3	1.34	.349E+00	27871.	15956.	.00601

RUN 693H, DATE 4/21/81, GAS HE XE, MOLECULAR WT. = 83.80
TIN = 71.9 F, TOUT = 444.7 F, MASS FLOW RATE = 29.4 LB/HR, I = 60.2 AMPS, E = 4.020 VOLTS
PR,IN = .251, GR/RESQ = .633E-02, MACH(2) = .068, MACH(16) = .086, T,SURR = 115.0 F, Q+(0) = .003369

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.281	185.1	1.215	15762.6	138.64	33513.	195.33
3	.3	2.026	224.5	1.287	3756.9	24.73	33430.	34.79
4	.5	.299	257.6	1.346	8777.4	47.74	33353.	67.06
5	.8	.211	283.5	1.390	9433.8	45.32	33254.	63.52
6	1.3	.117	321.3	1.452	10250.7	42.26	33038.	58.94
7	2.2	.088	363.3	1.513	10553.4	37.88	32685.	52.38
8	4.3	.077	425.2	1.563	10709.8	32.93	31812.	44.55
9	7.7	.088	481.1	1.614	10647.9	29.81	30561.	39.60
10	10.8	.099	518.1	1.615	10567.6	28.44	29472.	36.11
11	17.4	.125	577.1	1.592	10368.5	26.96	27519.	32.30
12	23.9	.169	619.8	1.552	10004.9	26.13	25899.	29.74
13	30.5	.195	651.3	1.502	9810.0	26.40	24499.	28.74
14	37.1	.225	681.3	1.459	9591.0	26.82	23297.	27.87
15	43.6	.252	706.2	1.415	9399.2	27.57	22253.	27.54
16	48.1	.278	725.9	1.392	9220.6	27.72	21614.	27.01
17	52.5	.298	741.1	1.367	9088.2	28.31	21039.	26.95
18	56.6	.756	756.7	1.351	6720.7	21.40	20592.	19.99
19	58.7	*****	679.0	1.262	-4119.7	-17.55	20571.	-15.35
20	59.3	-.192	540.0	1.165	14394.9	153.58	20552.	142.72

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	38.6	1.00	71.0	-.685E-01
2	54.2	38.1	1.36	426.6	.154E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
570.5	218.8	1.52	.462E+00	27180.	12437.	.00599

RUN 694H, DATE 4/21/81, GAS HE XE, MOLECULAR WT. = 83.80
TIN = 72.3 F, TOUT = 598.2 F, MASS FLOW RATE = 29.3 LB/HR, I = 74.0 AMPS, E = 5.030 VOLTS
PR,IN = .251, GR/RESQ = .984E-02, MACH(2) = .066, MACH(16) = .093, T,SURR = 149.0 F, Q+(8) = .005117

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.289	243.7	1.325	24168.4	140.70	33328.	195.22
3	.3	2.143	301.6	1.429	5497.9	24.10	33203.	33.67
4	.5	.272	349.3	1.513	13633.8	49.77	33086.	69.79
5	.8	.189	387.1	1.577	14621.1	47.27	32933.	66.06
6	1.3	.126	444.9	1.668	15505.7	42.87	32606.	59.45
7	2.2	.097	508.6	1.757	15993.1	38.39	32081.	52.50
8	4.3	.090	603.0	1.850	16206.0	33.24	30810.	44.05
9	7.7	.109	686.3	1.876	16014.3	29.97	29062.	37.83
10	10.9	.128	758.9	1.858	15808.2	28.60	27610.	34.59
11	17.4	.168	817.7	1.789	15350.2	27.29	25143.	30.49
12	23.9	.274	872.2	1.711	14125.7	25.57	23257.	26.73
13	30.5	.321	909.3	1.629	13658.2	25.90	21733.	25.53
14	37.1	.373	943.6	1.560	13172.4	26.24	20479.	24.57
15	43.7	.451	985.8	1.511	12494.1	25.64	19438.	22.94
16	48.2	.507	1010.5	1.480	12053.3	25.38	18825.	22.00
17	52.6	.536	1023.9	1.442	11833.4	26.13	18285.	22.10
18	56.6	1.132	1039.9	1.418	8535.5	19.41	17670.	16.12
19	58.8	*****	968.0	1.295	-11228.4	-36.24	17911.	-30.11
20	59.5	-.179	736.5	1.131	21705.9	159.39	17912.	132.63

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	38.5	1.00	71.5	-.686E-01
2	54.3	37.9	1.43	532.1	.192E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
801.1	290.5	1.68	.571E+00	25721.	9895.	.00604

RUN 695H, DATE 4/21/81, GAS HE XE, MOLECULAR WT. = 83.80
TIN = 72.8 F, TOUT = 735.5 F, MASS FLOW RATE = 29.9 LB/HR, I = 87.2 AMPS, E = 5.923 VOLTS
PR,IN = .251, GR/RESQ = .129E-01, MACH(2) = .070, MACH(16) = .101, T,SURR = 203.0 F, Q+(6) = .000004

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.304	327.6	1.482	34519.7	135.11	33947.	190.37
3	.3	2.480	408.6	1.627	6944.3	20.79	33771.	29.20
4	.5	.259	475.2	1.744	19291.3	48.45	33610.	67.85
5	.8	.208	529.4	1.833	20175.5	44.94	33397.	62.64
6	1.3	.146	612.5	1.961	21396.4	40.77	32949.	56.25
7	2.2	.113	703.9	2.082	22172.2	36.71	32234.	49.79
8	4.3	.120	841.8	2.204	22248.6	31.33	30556.	40.69
9	7.7	.161	960.5	2.222	21638.7	27.74	28339.	33.86
10	10.9	.193	1027.0	2.172	21154.8	26.41	26590.	30.55
11	17.5	.256	1117.3	2.036	20218.1	25.24	23768.	26.54
12	24.0	.488	1169.2	1.905	17120.4	22.17	21778.	21.62
13	30.6	.536	1192.2	1.778	16613.4	23.04	20277.	21.11
14	37.2	.585	1212.6	1.671	16118.0	24.08	19045.	20.87
15	43.8	.621	1226.9	1.576	15775.1	25.68	18019.	21.20
16	48.3	.673	1244.4	1.527	15301.2	26.14	17409.	20.92
17	52.7	.708	1256.1	1.479	15004.5	27.15	16869.	21.12
18	56.9	1.227	1271.8	1.446	11517.6	21.67	16451.	16.49
19	59.0	*****	1117.7	1.322	-17929.9	-46.97	16516.	-35.77
20	59.6	-.169	911.6	1.147	30122.2	173.91	16526.	131.98

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	38.3	1.00	71.9	-.683E-01
2	54.4	37.7	1.46	717.2	.212E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
1068.5	355.5	1.87	.656E+00	25330.	6115.	.00526

RUN 636H, DATE 4/29/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 74.6 F, TOUT = 634.3 F, MASS FLOW RATE = 33.6 LB/HR, I = 114.4 AMPS, E = 7.766 VOLTS
PR,IN = .214, CR/RESQ = .760E-02, MACH(2) = .053, MACH(16) = .074, T,SURR = 195.3 F, Q+(8) = .005320

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.168	291.7	1.403	49639.1	230.46	36183.	125.35
3	.3	.521	357.6	1.520	27263.8	97.62	36044.	52.97
4	.5	.127	407.9	1.606	36934.4	112.91	35863.	61.06
5	.8	.081	445.5	1.667	38625.3	106.69	35711.	57.51
6	1.3	.046	501.1	1.751	40053.9	97.28	35354.	52.03
7	2.2	.037	565.4	1.836	40612.9	87.07	34790.	45.97
8	4.3	.038	671.9	1.942	40857.5	74.51	33453.	38.10
9	7.7	.050	777.3	1.991	40694.5	66.14	31599.	32.25
10	10.9	.061	848.2	1.989	40460.7	62.27	30060.	29.11
11	17.4	.087	960.9	1.942	39812.5	57.83	27426.	25.00
12	23.9	.154	1038.5	1.867	37694.8	54.24	25360.	21.90
13	30.6	.182	1087.0	1.774	36912.5	54.77	23696.	20.64
14	37.2	.212	1129.4	1.691	36118.4	55.71	22310.	20.11
15	43.7	.237	1162.4	1.613	35455.3	57.63	21144.	19.63
16	48.2	.262	1189.8	1.571	34832.4	58.23	20442.	19.44
17	52.6	.280	1210.2	1.528	34376.0	59.71	19818.	19.39
18	56.8	.399	1233.9	1.496	31503.5	56.23	19290.	17.82
19	58.9	*****	1181.2	1.439	-3052.3	-6.11	19193.	-1.93
20	59.5	-.098	1002.0	1.278	48123.6	152.20	19174.	47.76

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	82.6	1.00	76.3	-.673E-01
2	54.4	81.8	1.51	650.8	.195E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
941.2	313.6	1.81	.756E+00	27897.	9702.	.00545

RUN 697H, DATE 4/29/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 76.3 F, TOUT = 560.2 F, MASS FLOW RATE = 32.4 LB/HR, I = 99.1 AMPS, E = 6.642 VOLTS
PR, IN = .214, GK/RESC = .534E-02, MACH(2) = .055, MACH(16) = .073, T,SURR = 146.5 F, Q+(6) = .004104

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.160	233.9	1.296	36663.6	232.02	34994.	126.21
3	.3	.525	284.7	1.387	20284.9	97.88	34891.	53.15
4	.5	.125	322.6	1.452	27564.4	113.32	34771.	61.39
5	.8	.081	351.1	1.499	28746.9	106.60	34643.	57.59
6	1.3	.047	392.5	1.563	29766.8	97.10	34376.	52.14
7	2.2	.034	433.3	1.625	30245.1	87.66	33953.	46.60
8	4.3	.034	513.9	1.703	30425.2	75.75	32928.	39.27
9	7.7	.042	590.2	1.747	30357.7	67.70	31476.	33.79
10	10.9	.043	639.6	1.748	30280.5	64.43	30230.	31.06
11	17.4	.064	723.3	1.724	29997.1	60.46	28024.	27.35
12	23.9	.098	785.0	1.677	29207.5	58.20	26217.	24.65
13	30.5	.117	831.2	1.618	28795.6	58.49	24662.	23.67
14	37.1	.139	874.6	1.565	28330.2	58.90	23355.	22.73
15	43.7	.159	911.2	1.514	27895.1	60.10	22236.	22.22
16	48.1	.178	939.6	1.486	27501.2	60.25	21552.	21.67
17	52.5	.194	962.5	1.456	27183.1	61.18	20937.	21.45
18	56.7	.324	986.9	1.435	24547.3	56.17	20417.	19.26
19	58.8	*****	945.1	1.382	2706.7	6.99	20298.	2.38
20	59.4	-.099	602.9	1.238	35611.0	147.47	20269.	50.07

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	77.4	1.00	75.8	-.678E-01
2	54.2	76.7	1.45	531.3	.174E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
719.4	260.9	1.64	.675E+00	27656.	11493.	.00586

RUN 698H, DATE 4/29/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 76.3 F, TOUT = 464.6 F, MASS FLOW RATE = 31.8 LB/HR, I = 87.2 AMPS, E = 5.633 VOLTS
PR,IN = .214, GR/RESQ = .389E-02, MACH(2) = .057, MACH(16) = .072, T,SURR = 129.5 F, Q+(6) = .003232

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COFF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.156	199.9	1.232	28226.9	227.78	34280.	123.66
3	.3	.519	239.6	1.303	15727.5	96.83	34200.	52.59
4	.5	.139	270.0	1.356	21018.6	109.81	34108.	59.52
5	.8	.082	292.2	1.393	22153.7	104.53	34010.	56.53
6	1.3	.045	323.7	1.442	22997.6	95.85	33803.	51.60
7	2.2	.033	358.7	1.491	23329.0	86.69	33474.	46.30
8	4.3	.031	415.6	1.552	23463.1	75.43	32666.	39.48
9	7.7	.037	472.6	1.589	23434.4	67.91	31504.	34.46
10	10.6	.041	511.1	1.594	23396.1	64.76	30487.	31.98
11	17.4	.053	576.8	1.584	23243.4	60.89	28632.	28.51
12	23.9	.072	626.4	1.555	22912.7	59.20	27060.	26.40
13	30.5	.085	664.9	1.514	22710.2	59.62	25674.	25.41
14	37.1	.099	702.2	1.476	22470.0	60.09	24456.	24.54
15	43.6	.114	736.2	1.440	22222.2	60.93	23395.	23.94
16	48.1	.127	761.9	1.421	21998.8	60.91	22742.	23.35
17	52.5	.137	783.3	1.400	21813.4	61.61	22150.	23.06
18	56.7	.263	805.3	1.384	19687.6	56.22	21645.	20.64
19	58.7	3.828	774.9	1.340	5140.4	16.47	21509.	6.01
20	59.3	-.098	660.1	1.212	27306.9	140.41	21475.	51.05

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	73.7	1.00	75.6	-.681E-01
2	54.2	73.0	1.39	439.9	.154E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
577.0	222.4	1.52	.601E+00	28108.	13147.	.00596

RUN 699H, DATE 4/29/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 75.9 F, TOUT = 299.1 F, MASS FLOW RATE = 32.1 LB/HR, I = 66.2 AMPS, E = 4.423 VOLTS
PR,IN = .214, GR/RESQ = .207E-02, MACH(2) = .059, MACH(16) = .069, T,SURR = 103.0 F, Q+(3) = .001829

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.142	147.3	1.135	15924.6	221.82	34686.	120.66
3	.3	.453	169.9	1.176	9170.5	97.91	34640.	53.22
4	.5	.135	186.9	1.205	12076.3	110.01	34587.	59.73
5	.8	.070	199.1	1.226	12826.6	105.94	34530.	57.49
6	1.3	.041	216.7	1.254	13194.7	96.55	34410.	52.21
7	2.2	.031	236.2	1.282	13352.0	87.34	34219.	47.02
8	4.3	.028	267.5	1.320	13411.8	76.31	33741.	40.60
9	7.6	.032	299.2	1.345	13394.1	68.69	33033.	36.01
10	10.8	.035	319.8	1.352	13384.7	66.06	32394.	33.97
11	17.4	.042	357.1	1.357	13326.5	62.17	31169.	30.93
12	23.8	.049	385.7	1.348	13262.1	60.93	30063.	29.40
13	30.4	.055	409.9	1.332	13213.1	61.07	29035.	28.60
14	37.0	.061	433.9	1.318	13154.6	61.18	28095.	27.85
15	43.5	.069	457.9	1.305	13067.7	61.15	27239.	27.10
16	48.0	.074	474.3	1.297	13037.5	61.12	26659.	26.62
17	52.4	.080	490.1	1.289	12982.9	61.10	26176.	26.17
18	56.5	.161	504.1	1.282	11885.3	56.26	25730.	23.74
19	58.6	1.623	487.1	1.251	5342.6	28.26	25587.	11.66
20	59.2	-.094	420.1	1.159	15390.2	128.05	25548.	53.63

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	71.4	1.00	75.3	-.679E-01
2	54.1	70.8	1.29	283.6	.116E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
359.8	158.7	1.33	.485E+00	30334.	18028.	.00608

RUN 700H, DATE 4/29/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 75.4 F, TOUT = 165.2 F, MASS FLOW RATE = 32.2 LB/HR, I = 42.3 AMPS, E = 2.787 VOLTS
PR,IN = .714, GR/RESQ = .754E-03, MACH(2) = .062, MACH(16) = .067, T,SURR = 87.5 F, Q+(6) = .000736

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.136	104.8	1.056	6423.0	216.16	34865.	117.63
3	.3	.482	114.0	1.073	3747.6	97.20	34846.	52.67
4	.5	.122	120.6	1.085	4953.8	110.46	34824.	60.06
5	.8	.072	125.5	1.093	5187.4	105.02	34801.	57.07
6	1.3	.039	132.2	1.104	5351.9	96.79	34752.	52.54
7	2.2	.029	139.4	1.115	5410.4	88.48	34674.	47.94
8	4.3	.026	150.5	1.128	5430.0	78.66	34476.	42.53
9	7.6	.029	162.5	1.139	5416.6	71.68	34175.	36.37
10	10.8	.031	170.4	1.143	5410.1	68.68	33694.	36.62
11	17.3	.037	185.0	1.148	5386.3	65.02	33335.	34.06
12	23.8	.044	195.9	1.147	5354.4	63.98	32810.	33.06
13	30.4	.047	206.0	1.144	5339.0	63.92	32295.	32.61
14	37.0	.052	217.0	1.143	5320.1	63.05	31799.	31.74
15	43.5	.056	227.5	1.142	5303.6	62.60	31331.	31.12
16	47.9	.060	235.2	1.141	5289.8	61.83	31018.	30.48
17	52.3	.063	242.4	1.141	5277.1	61.31	30716.	29.97
18	56.5	.132	249.8	1.140	4956.6	57.50	30447.	27.89
19	58.5	.617	243.1	1.126	3085.9	39.53	30347.	19.12
20	59.1	-.061	216.4	1.062	6092.5	120.52	30319.	56.23

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	67.9	1.00	74.7	-.678E-01
2	54.0	67.5	1.14	158.6	.846E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
185.8	108.7	1.14	.370E+00	32732.	25701.	.00588

RUN 701H, DATE 5/13/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 75.0 F, TOUT = 541.1 F, MASS FLOW RATE = 54.2 LB/HR, I = 123.6 AMPS, E = 8.300 VOLTS
PR,IN = .214, GR/RESQ = .714E-02, MACH(2) = .060, MACH(16) = .079, T,SURR = 141.0 F, Q+(6) = .003872

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.122	255.3	1.339	54755.0	302.93	58657.	165.16
3	.3	.354	314.9	1.447	35651.1	149.22	58487.	81.22
4	.5	.104	356.8	1.520	43847.3	157.23	58285.	85.38
5	.8	.056	386.2	1.569	45938.9	150.00	58079.	81.24
6	1.3	.033	427.9	1.633	47120.1	137.07	57650.	73.82
7	2.2	.025	474.6	1.698	47635.4	124.21	56975.	66.26
8	4.3	.025	551.1	1.779	47890.8	108.31	55341.	56.42
9	7.7	.031	627.7	1.825	47881.9	97.53	53016.	49.01
10	10.9	.036	677.7	1.827	47835.2	93.00	51006.	45.24
11	17.4	.047	762.0	1.806	47594.5	87.43	47422.	39.97
12	23.9	.074	829.3	1.766	46605.0	83.45	44452.	36.10
13	30.5	.089	879.2	1.710	46128.5	83.11	41886.	34.14
14	37.1	.106	926.5	1.659	45572.8	82.91	39683.	32.48
15	43.7	.121	964.9	1.606	45071.6	84.01	37801.	31.54
16	48.2	.135	995.6	1.579	44599.9	83.79	36644.	30.62
17	52.5	.147	1020.3	1.549	44208.1	84.54	35603.	30.12
18	56.8	.219	1041.6	1.521	41676.0	81.28	34702.	28.31
19	58.8	2.432	1013.0	1.477	14768.1	31.16	34436.	10.77
20	59.4	-.050	974.8	1.333	52889.2	159.18	34380.	54.81

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	117.8	1.00	74.3	-.600E-01
2	54.3	116.6	1.54	510.2	.158E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
762.3	250.3	1.72	.112E+01	46946.	17701.	.00509

RUN 702H, DATE 5/13/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 76.3 F, TOUT = 407.7 F, MASS FLOW RATE = 55.2 LB/HR, I = 104.4 AMPS, E = 7.016 VOLTS
PR.IN = .214, GR/RESQ = .470E-02, MACH(2) = .062, MACH(16) = .076, T,SURR = 124.0 F, Q+(8) = .002689

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.110	208.6	1.249	38378.1	269.27	59602.	157.35
3	.3	.338	250.4	1.324	25605.6	147.62	59463.	80.20
4	.5	.097	279.1	1.374	31317.2	155.97	59339.	84.60
5	.8	.057	299.4	1.409	32544.2	148.10	59193.	80.19
6	1.3	.029	326.9	1.452	33502.5	137.17	58889.	73.97
7	2.2	.022	357.7	1.495	33797.9	125.07	58407.	67.00
8	4.3	.021	408.1	1.552	33946.9	110.12	57219.	58.00
9	7.7	.025	459.0	1.588	33960.1	99.95	55500.	51.32
10	10.8	.027	492.5	1.596	33958.1	95.69	53968.	47.99
11	17.4	.034	550.9	1.593	33876.3	90.23	51124.	43.22
12	23.9	.044	596.0	1.572	33641.7	87.78	48649.	40.29
13	30.5	.052	632.7	1.540	33497.8	87.64	46421.	38.64
14	37.1	.060	669.9	1.512	33308.1	87.22	44443.	37.04
15	43.6	.069	701.3	1.481	33128.0	88.02	42672.	36.07
16	48.1	.076	724.4	1.464	32966.2	88.09	41555.	35.26
17	52.4	.081	743.6	1.444	32834.1	89.03	40546.	34.86
18	56.6	.150	763.8	1.429	30923.8	84.45	39663.	32.46
19	58.7	1.102	746.2	1.395	16892.8	49.66	39359.	18.95
20	59.3	-.034	651.8	1.282	36513.8	150.23	39288.	57.16

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	117.3	1.00	75.6	-.597E-01
2	54.2	116.3	1.44	384.0	.128E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
553.3	198.9	1.54	.951E+00	49891.	22782.	.00509

RUN 703H, DATE 5/13/81, GAS HE XE, MOLECULAR WT. = 39.95

TIN = 76.8 F, TOUT = 287.4 F, MASS FLOW RATE = 57.0 LB/HR, I = 84.6 AMPS, E = 5.602 VOLTS

PR,IN = .214, GR/RESQ = .296E-02, MACH(2) = .064, MACH(16) = .074, T,SURR = 99.5 F, Q+(8) = .001696

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.096	158.8	1.155	24716.2	299.79	61534.	162.90
3	.3	.309	184.9	1.202	17104.3	156.64	61457.	86.14
4	.5	.095	202.2	1.232	20480.5	164.81	61362.	89.39
5	.8	.042	214.0	1.252	21535.1	159.30	61266.	86.30
6	1.3	.026	230.7	1.279	21902.1	145.98	61067.	73.89
7	2.2	.020	249.3	1.306	22058.0	133.25	60750.	71.70
8	4.3	.019	279.2	1.342	22131.0	117.94	59962.	62.79
9	7.6	.021	309.2	1.366	22132.9	107.72	58787.	56.43
10	10.8	.022	328.5	1.372	22135.5	103.83	57726.	53.53
11	17.4	.026	363.0	1.375	22102.7	98.72	55677.	49.38
12	23.8	.031	390.6	1.367	22052.9	96.77	53809.	47.00
13	30.4	.034	413.8	1.353	22018.8	96.93	52067.	45.77
14	37.0	.038	437.3	1.340	21972.7	96.84	50462.	44.51
15	43.5	.042	459.0	1.326	21925.3	97.40	48987.	43.64
16	48.0	.045	474.0	1.317	21888.1	97.74	48034.	43.08
17	52.4	.043	488.9	1.309	21843.9	97.90	47148.	42.44
18	56.5	.102	501.5	1.300	20785.7	94.04	46353.	40.17
19	58.6	.625	490.7	1.275	14095.0	69.00	46052.	29.30
20	59.2	-.021	434.1	1.196	23284.8	159.68	45975.	67.65

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	117.3	1.00	76.0	-.593E-01
2	54.1	116.5	1.30	271.6	.997E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
366.0	154.1	1.35	.790E+00	54172.	31318.	.00493

RUN 704H, DATE 5/13/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 75.4 F, TOUT = 168.3 F, MASS FLOW RATE = 55.3 LB/HR, I = 55.7 AMPS, E = 3.684 VOLTS
PR,IN = .214, GR/RESQ = .125E-02, MACH(2) = .065, MACH(16) = .069, T,SURR = 67.5 F, Q+(8) = .000754

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.094	113.5	1.073	10652.1	277.14	59851.	150.83
3	.3	.312	124.9	1.093	7363.0	146.64	59817.	80.86
4	.5	.073	132.0	1.106	9008.0	160.23	59776.	87.13
5	.8	.052	137.4	1.115	9194.5	150.24	59735.	81.65
6	1.3	.023	144.0	1.126	9460.8	141.16	59648.	76.63
7	2.2	.019	151.5	1.137	9504.2	129.85	59510.	70.36
8	4.3	.018	163.9	1.153	9518.9	115.90	59163.	62.49
9	7.6	.020	176.4	1.164	9512.3	106.69	58635.	57.10
10	10.8	.021	184.7	1.168	9507.0	102.93	58142.	54.69
11	17.3	.024	198.7	1.171	9489.9	98.99	57162.	51.84
12	23.8	.028	210.9	1.172	9458.1	96.77	56237.	49.98
13	30.4	.030	221.7	1.169	9444.9	96.42	55329.	49.12
14	37.0	.033	233.0	1.167	9428.7	95.47	54457.	47.98
15	43.5	.035	243.4	1.165	9414.7	95.32	53630.	47.26
16	47.9	.037	250.7	1.163	9405.1	95.11	53078.	46.76
17	52.3	.039	258.4	1.162	9391.8	94.29	52548.	45.96
18	56.5	.080	264.7	1.160	9041.8	90.94	52067.	43.98
19	58.5	.388	260.8	1.149	7032.1	75.68	51868.	36.57
20	59.1	-.013	236.5	1.108	9869.4	146.22	51814.	70.39

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	112.5	1.00	74.7	-.597E-01
2	54.0	111.9	1.16	161.1	.748E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
201.2	109.6	1.16	.581E+00	56095.	42399.	.00498

RUN 705H, DATE 5/20/81, GAS HE XE, MOLECULAR WT. = 39.95
TIN = 79.0 F, TOUT = 527.0 F, MASS FLOW RATE = 57.5 LB/HR, I = 124.0 AMPS, E = 8.332 VOLTS
PR,IN = .215, GR/RESQ = .943E-02, MACH(2) = .052, MACH(16) = .068, T,SURR = 142.0 F, Q+(8) = .003650

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.113	253.0	1.325	54486.5	312.44	61772.	169.32
3	.3	.326	309.8	1.426	36629.7	159.42	61603.	86.25
4	.5	.096	348.4	1.493	44435.5	166.68	61400.	89.98
5	.8	.051	375.5	1.538	46410.5	159.07	61194.	85.66
6	1.3	.031	413.6	1.596	47466.3	143.60	60768.	77.96
7	2.2	.022	455.5	1.653	48018.8	132.98	60096.	70.59
8	4.3	.023	525.9	1.727	48231.7	116.35	58471.	60.39
9	7.7	.027	595.3	1.767	48255.6	105.47	56144.	52.91
10	10.9	.031	640.9	1.769	48235.4	100.93	54121.	49.09
11	17.4	.040	718.7	1.749	48064.2	95.37	50488.	43.72
12	23.9	.061	779.4	1.710	47342.9	92.12	47446.	40.04
13	30.5	.072	826.5	1.658	46979.4	92.13	44795.	38.10
14	37.1	.087	874.2	1.615	46513.5	91.74	42491.	36.21
15	43.7	.099	912.1	1.567	46101.8	93.09	40522.	35.26
16	48.1	.111	942.2	1.542	45705.9	92.96	39304.	34.28
17	52.5	.120	964.6	1.512	45416.5	94.37	38205.	33.94
18	56.7	.187	989.0	1.489	42919.2	90.35	37249.	31.76
19	58.8	1.674	964.1	1.448	19019.8	43.26	36946.	15.10
20	59.4	-.038	839.2	1.317	52415.8	168.40	36880.	58.55

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	144.9	1.00	78.5	-.593E-01
2	54.2	143.8	1.50	496.2	.153E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
720.0	246.0	1.67	.100E+01	49795.	19748.	.00515

RUN 707H, DATE 5/23/81, GAS HF XE, MOLECULAR WT. = 28.30
TIN = 78.1 F, TOUT = 451.3 F, MASS FLOW RATE = 49.2 LB/HR, I = 123.6 AMPS, E = 8.255 VOLTS
PR,IN = .231, GR/RESQ = .448E-02, MACH(2) = .056, MACH(16) = .070, T,SURR = 126.0 F, Q+(E) = .003006

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.095	227.6	1.280	52989.7	353.66	53390.	147.52
3	.3	.271	277.3	1.369	37877.7	190.92	53272.	79.54
4	.5	.084	310.1	1.426	44506.5	193.79	53129.	80.59
5	.8	.044	332.6	1.464	46280.7	184.71	52986.	76.65
6	1.3	.023	363.3	1.511	47342.8	170.32	52692.	70.37
7	2.2	.019	398.7	1.560	47664.2	154.80	52226.	63.49
8	4.3	.018	456.3	1.624	47890.5	136.22	51087.	54.65
9	7.7	.022	515.9	1.666	47929.1	123.07	49436.	48.18
10	10.8	.024	554.0	1.672	47947.1	117.83	47988.	44.96
11	17.4	.031	620.4	1.665	47871.0	111.14	45306.	40.35
12	23.9	.043	673.4	1.641	47486.6	107.46	43004.	37.28
13	30.5	.050	715.3	1.603	47281.4	107.15	40945.	35.60
14	37.1	.060	758.5	1.572	46999.9	106.25	39123.	33.91
15	43.6	.069	793.8	1.535	46736.3	107.16	37496.	32.91
16	48.1	.075	818.2	1.513	46523.9	107.65	36500.	32.28
17	52.5	.082	841.4	1.491	46306.4	106.28	35589.	31.75
18	56.7	.137	863.6	1.473	44138.5	104.07	34790.	29.90
19	58.7	.971	848.8	1.441	25427.5	63.63	34507.	18.14
20	59.4	-.019	747.2	1.325	50728.5	172.06	34443.	48.89

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	135.7	1.00	77.6	-.613E-01
2	54.2	134.7	1.48	424.3	.141E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
623.9	215.9	1.60	.100E+01	44326.	19069.	.00540

RUN 708H, DATE 5/23/81, GAS HE XE, MOLECULAR WT. = 28.30
TIN = 79.9 F, TOUT = 289.0 F, MASS FLOW RATE = 51.2 LB/HR, I = 94.4 AMPS, E = 6.263 VOLTS
PR,IN = .231, GR/RESQ = .232E-02, MACH(2) = .059, MACH(16) = .068, T,SURR = 109.0 F, Q+(8) = .001663

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.078	168.6	1.166	30184.4	339.24	55449.	141.09
3	.3	.229	194.0	1.212	22697.6	199.52	55382.	82.92
4	.5	.076	210.8	1.241	25956.0	200.02	55298.	83.04
5	.8	.032	222.1	1.260	27088.1	193.36	55216.	80.18
6	1.3	.020	237.9	1.284	27449.8	178.19	55045.	73.71
7	2.2	.015	255.5	1.310	27606.9	163.66	54774.	67.42
8	4.3	.015	285.0	1.345	27679.0	145.35	54100.	59.25
9	7.6	.016	314.6	1.368	27695.9	133.14	53098.	53.41
10	10.8	.018	334.8	1.376	27701.9	127.77	52187.	50.50
11	17.4	.021	369.3	1.380	27685.2	121.54	50429.	46.63
12	23.8	.024	396.9	1.373	27647.4	119.14	48823.	44.44
13	30.4	.027	419.5	1.358	27625.5	119.58	47315.	43.40
14	37.0	.030	444.0	1.346	27587.3	118.96	45926.	42.06
15	43.5	.033	466.1	1.333	27549.1	119.39	44646.	41.17
16	48.0	.035	481.5	1.325	27517.1	119.55	43814.	40.55
17	52.4	.038	496.8	1.318	27479.3	119.57	43041.	39.93
18	56.6	.080	510.3	1.310	26437.9	115.63	42342.	38.06
19	58.6	.445	503.0	1.289	19751.5	91.79	42065.	30.03
20	59.2	.000	452.7	1.219	28424.4	174.52	41994.	56.97

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	133.9	1.00	79.3	-.607E-01
2	54.1	133.0	1.31	272.9	.105E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
372.3	156.4	1.35	.823E+00	49098.	28428.	.00538

RUN 709H, DATE 5/23/81, GAS HE XE, MOLECULAR WT. = 28.30
TIN = 80.3 F, TOUT = 691.8 F, MASS FLOW RATE = 44.8 LB/HR, I = 152.4 AMPS, E = 10.270 VOLTS
PR,IN = .231, GR/RESQ = .667E-02, MACH(2) = .057, MACH(16) = .078, T,SURR = 196.5 F, Q+(6) = .005064

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.111	326.2	1.457	82585.8	335.29	48411.	139.55
3	.3	.290	402.7	1.594	57251.7	178.41	48232.	74.10
4	.5	.077	454.3	1.661	66837.5	186.12	48016.	77.06
5	.8	.045	492.2	1.742	71170.3	175.67	47798.	72.48
6	1.3	.030	548.7	1.827	72435.9	158.85	47351.	65.06
7	2.2	.023	611.1	1.908	73310.2	143.98	46655.	58.26
8	4.3	.024	714.5	2.008	73752.5	125.22	44998.	49.17
9	7.7	.032	821.6	2.061	73723.9	111.85	42687.	41.99
10	10.9	.038	889.7	2.055	73624.1	106.38	40746.	36.37
11	17.4	.054	1004.2	2.010	73115.0	99.52	37378.	33.31
12	24.0	.095	1085.2	1.935	70724.3	94.64	34665.	29.68
13	30.6	.113	1138.9	1.842	69852.3	95.73	32449.	28.25
14	37.2	.133	1190.7	1.763	68846.8	96.59	30585.	27.04
15	43.8	.150	1230.2	1.684	68001.8	99.23	29007.	26.48
16	48.3	.165	1259.9	1.640	67285.1	100.50	28049.	26.02
17	52.7	.176	1282.6	1.594	66735.1	102.99	27192.	25.92
18	56.9	.224	1308.0	1.559	64219.7	101.61	26448.	24.93
19	58.9	3.050	1287.1	1.523	19378.3	32.40	26234.	7.86
20	59.6	-.037	1125.0	1.376	80650.9	186.92	26195.	45.29

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	122.5	1.00	79.8	-.627E-01
2	54.4	121.3	1.58	651.6	.186E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,b,MOD,AV	F,B,AV
990.2	311.7	1.86	.122E+01	37661.	12445.	.00505

RUN 710H, DATE 5/23/81, GAS HE XE, MOLECULAR WT. = 28.30
TIN = 80.3 F, TOUT = 168.3 F, MASS FLOW RATE = 45.3 LB/HR, I = 58.0 AMPS, E = 3.786 VOLTS
PR,IN = .231, GR/RESQ = .806E-03, MACH(2) = .062, MACH(16) = .066, T,SURR = 103.7 F, Q+(8) = .000705

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.079	119.5	1.074	11374.0	288.42	49001.	119.83
3	.3	.227	129.0	1.091	8539.4	175.31	48976.	72.81
4	.5	.088	135.7	1.103	9635.9	175.21	48945.	72.74
5	.8	.027	139.7	1.109	10209.0	174.14	48914.	72.26
6	1.3	.016	145.4	1.118	10324.6	162.39	48850.	67.31
7	2.2	.014	152.1	1.128	10355.4	150.22	48748.	62.16
8	4.3	.013	162.7	1.141	10375.5	136.00	48491.	56.02
9	7.6	.015	174.6	1.152	10364.7	124.61	48100.	50.97
10	10.8	.015	182.5	1.156	10360.9	120.12	47734.	48.82
11	17.3	.018	196.1	1.160	10344.3	115.06	47009.	46.14
12	23.8	.022	206.2	1.158	10317.6	114.45	46319.	45.31
13	30.4	.023	215.4	1.154	10307.1	115.26	45638.	45.04
14	37.0	.026	225.8	1.152	10292.8	114.49	44986.	44.19
15	43.5	.027	235.3	1.149	10281.4	114.77	44365.	43.76
16	47.9	.029	242.1	1.147	10273.1	114.60	43950.	43.34
17	52.3	.030	249.3	1.147	10262.1	113.65	43550.	42.63
18	56.5	.060	255.7	1.146	9976.1	110.31	43184.	41.08
19	58.5	.261	253.0	1.137	8385.8	96.61	43026.	36.60
20	59.1	.010	234.3	1.105	10459.2	159.86	42983.	59.27

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	113.7	1.00	79.7	-.625E-01
2	54.0	113.1	1.15	161.3	.781E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
197.3	112.6	1.15	.566E+00	46197.	35809.	.00538

RUN 711H, DATE 6/2/81 , GAS HE XE, MOLECULAR WT. = 14.50
TIN = 85.3 F, TOUT = 162.7 F, MASS FLOW RATE = 36.0 LB/HR, I = 67.6 AMPS, E = 4.392 VOLTS
PR, IN = .301, GR/RESQ = .5C3E-03, MACH(2) = .054, MACH(16) = .057, T,SURR = 82.5 F, Q+(8) = .000612

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.068	118.7	1.062	15263.6	453.56	40869.	132.07
3	.3	.201	130.5	1.084	11849.2	261.86	40851.	76.23
4	.5	.082	138.1	1.097	13165.4	250.98	40829.	73.03
5	.8	.027	142.5	1.104	13877.2	245.42	40808.	71.39
6	1.3	.016	148.2	1.113	14030.7	227.81	40764.	66.20
7	2.2	.013	154.4	1.123	14077.6	211.18	40694.	61.28
8	4.3	.013	164.6	1.135	14094.6	190.52	40520.	55.08
9	7.6	.014	175.2	1.145	14090.5	175.79	40252.	50.51
10	10.8	.014	182.2	1.149	14089.1	169.89	40002.	48.54
11	17.3	.016	194.5	1.153	14077.6	162.78	39508.	45.99
12	23.8	.019	204.5	1.153	14052.0	159.82	39033.	44.66
13	30.4	.020	212.4	1.150	14045.8	161.38	38562.	44.59
14	37.0	.021	220.9	1.147	14036.9	161.61	38108.	44.18
15	43.5	.022	229.5	1.145	14028.8	161.59	37675.	43.71
16	47.9	.024	236.3	1.145	14020.4	159.88	37383.	42.94
17	52.3	.025	242.7	1.145	14013.2	158.82	37102.	42.36
18	56.5	.048	248.1	1.143	13706.3	155.41	36840.	41.18
19	58.5	.198	247.3	1.137	11991.3	141.27	36725.	37.33
20	59.1	.016	230.3	1.109	14119.3	210.13	36694.	55.47

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	144.7	1.00	84.7	-.653E-01
2	54.0	144.1	1.14	156.4	.774E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
195.5	113.6	1.14	.548E+00	38929.	30649.	.00555

RUN 712H, DATE 6/2/81 , GAS HE XE, MOLECULAR WT. = 14.50
TIN = 83.9 F, TOUT = 254.1 F, MASS FLOW RATE = 35.6 LB/HR, I = 99.0 AMPS, E = 6.398 VOLTS
PR,11 = .301, GR/RESQ = .109E-02, MACH(2) = .054, MACH(16) = .061, T,SURR = 94.5 F, Q+(8) = .001337

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.062	157.2	1.136	32623.3	443.99	40554.	129.57
3	.3	.184	180.9	1.179	25897.2	267.76	40515.	78.10
4	.5	.063	195.6	1.204	28859.3	260.70	40468.	75.97
5	.8	.028	205.2	1.220	29859.6	249.75	40422.	72.71
6	1.3	.015	217.6	1.239	30288.0	232.22	40327.	67.47
7	2.2	.012	231.6	1.259	30397.2	214.05	40177.	62.00
8	4.3	.012	255.2	1.288	30459.5	191.21	39802.	54.92
9	7.6	.013	279.6	1.309	30473.8	175.11	39243.	49.66
10	10.8	.014	295.0	1.314	30488.4	169.24	38732.	47.43
11	17.4	.016	322.4	1.319	30483.8	161.69	37729.	44.24
12	23.8	.018	343.6	1.313	30465.2	159.66	36802.	42.71
13	30.4	.020	360.5	1.300	30460.0	161.51	35917.	42.25
14	37.0	.022	378.9	1.290	30445.8	162.11	35082.	41.50
15	43.5	.023	395.9	1.279	30432.1	163.76	34308.	41.07
16	48.0	.025	408.1	1.272	30419.4	164.37	33798.	40.65
17	52.3	.026	420.6	1.267	30400.5	164.33	33321.	40.12
18	56.5	.055	431.2	1.260	29596.0	161.35	32883.	38.92
19	58.6	.262	427.3	1.246	24725.1	141.91	32696.	34.04
20	59.2	.015	392.4	1.194	30667.0	222.73	32648.	53.33

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	143.2	1.00	83.4	-.654E-01
2	54.1	142.5	1.26	240.6	.977E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
323.6	145.9	1.29	.664E+00	36845.	23353.	.00555

RUN 713H, DATE 6/2/81 , GAS HE XE, MOLECULAR WT. = 14.50
TIN = 63.9 F, TOUT = 432.9 F, MASS FLOW RATE = 31.1 LB/HR, I = 131.9 AMPS, E = 8.620 VOLTS
PP,IN = .301, GF/RESQ = .181E-02, MACH(2) = .056, MACH(16) = .069, T,SURR = 121.5 F, Q+(8) = .002749

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.077	225.5	1.262	59181.9	417.00	35374.	121.77
3	.3	.215	272.9	1.347	45102.1	239.62	35306.	69.90
4	.5	.068	303.3	1.399	51443.0	236.62	35222.	68.96
5	.8	.045	324.5	1.434	52657.5	222.30	35140.	64.61
6	1.3	.015	349.2	1.471	54303.8	210.07	34973.	60.81
7	2.2	.015	360.9	1.515	54390.1	190.71	34706.	54.84
8	4.3	.015	431.0	1.568	54636.1	169.47	34060.	47.94
9	7.7	.017	482.7	1.603	54708.4	154.54	33114.	42.62
10	10.8	.019	516.4	1.608	54748.7	148.54	32279.	40.03
11	17.4	.023	574.3	1.600	54736.4	141.37	30714.	36.41
12	23.9	.031	618.6	1.574	54512.8	136.68	29345.	34.31
13	30.5	.035	651.3	1.533	54415.8	141.08	28109.	33.50
14	37.1	.040	682.9	1.496	54287.1	143.63	27000.	32.86
15	43.6	.044	711.6	1.459	54152.4	147.22	25963.	32.45
16	48.1	.049	734.3	1.440	54017.9	148.44	25345.	32.00
17	52.5	.052	754.3	1.420	53896.9	150.59	24776.	31.79
18	56.7	.092	774.4	1.403	52019.4	147.13	24270.	30.47
19	58.7	.551	765.5	1.377	36598.7	109.36	24073.	22.48
20	59.3	.007	689.2	1.287	56061.5	219.66	24027.	45.00

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	121.2	1.00	83.4	-.676E-01
2	54.2	120.2	1.41	406.4	.142E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
573.1	211.6	1.54	.892E+00	29972.	14150.	.00589

RUN 714H, DATE 6/2/81 , GAS HE XE, MOLECULAR WT. = 14.50

TIN = 85.3 F, TOUT = 564.9 F, MASS FLOW RATE = 30.3 LB/HR, I = 152.7 AMPS, E = 10.300 VOLTS

PR,IN = .301, GP/RESQ = .245E-02, MACH(2) = .056, MACH(16) = .073, T,SLRR = 159.0 F, Q+(8) = .003799

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.062	279.5	1.358	80061.3	411.42	34429.	119.98
3	.3	.209	339.9	1.465	61044.5	240.60	34338.	70.11
4	.5	.064	379.9	1.533	69564.6	238.63	34225.	69.32
5	.8	.038	408.1	1.579	71460.3	224.93	34115.	65.17
6	1.3	.020	446.6	1.636	72902.2	207.19	33890.	59.70
7	2.2	.015	489.6	1.692	73486.5	189.46	33537.	54.10
8	4.3	.016	562.8	1.767	73832.4	166.58	32689.	46.51
9	7.7	.020	637.4	1.809	73960.9	150.95	31474.	40.74
10	10.9	.022	686.3	1.810	74008.1	144.47	30419.	37.81
11	17.4	.029	767.4	1.784	73943.2	137.24	28509.	33.86
12	23.9	.046	838.6	1.751	73095.7	131.46	26899.	30.75
13	30.5	.054	884.6	1.689	72762.7	132.82	25456.	29.51
14	37.1	.065	933.4	1.639	72293.8	133.29	24243.	28.31
15	43.7	.073	970.9	1.584	71688.1	136.51	23190.	27.82
16	48.2	.082	1000.7	1.555	71483.7	137.43	22534.	27.27
17	52.6	.086	1016.7	1.515	71308.5	142.44	21940.	27.57
18	56.8	.126	1042.2	1.490	68842.4	139.67	21415.	26.43
19	58.8	.882	1030.7	1.461	41162.3	87.84	21226.	16.48
20	59.4	-.002	918.6	1.345	77021.2	216.60	21187.	40.65

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	118.7	1.00	84.7	-.681E-01
2	54.3	117.6	1.50	529.7	.172E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
770.7	262.2	1.70	.106E+01	28082.	11185.	.00605

RUN 715H, DATE 6/2/81 , GAS HE XE, MOLECULAR WT. = 14.50
TIN = 85.7 F, TOUT = 673.7 F, MASS FLOW RATE = 30.0 LB/HR, I = 168.7 AMPS, E = 11.420 VOLTS
PR,IN = .301, GR/RESQ = .305E-02, MACH(2) = .055, MACH(16) = .075, T,SURR = 202.0 F, Q+(8) = .004717

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.092	331.3	1.452	99157.1	403.12	34042.	117.54
3	.3	.219	405.4	1.563	74236.1	233.27	33930.	67.69
4	.5	.067	457.0	1.670	85175.0	231.68	33792.	67.28
5	.8	.038	493.5	1.729	87774.0	216.70	33657.	63.26
6	1.3	.023	545.9	1.806	89373.2	199.29	33380.	57.26
7	2.2	.017	603.9	1.881	90310.1	181.44	32954.	51.56
8	4.3	.019	704.6	1.982	90787.0	157.51	31927.	43.54
9	7.7	.024	806.1	2.034	90937.7	141.42	30487.	37.52
10	10.9	.029	875.2	2.037	90909.1	133.69	29261.	34.23
11	17.4	.040	978.8	1.989	90647.1	126.86	27102.	30.25
12	23.9	.069	1059.8	1.924	88619.7	121.58	25311.	27.22
13	30.6	.082	1113.4	1.837	87889.1	122.61	23819.	25.99
14	37.2	.097	1167.7	1.764	86972.7	123.58	22559.	24.87
15	43.6	.110	1207.6	1.689	86229.9	127.02	21478.	24.41
16	48.2	.122	1240.7	1.649	85508.4	128.04	20813.	23.90
17	52.7	.130	1264.7	1.606	84985.9	130.98	20215.	23.79
18	56.9	.167	1290.1	1.570	82470.7	130.12	19691.	23.05
19	58.9	1.437	1268.9	1.532	39426.0	65.91	19518.	11.57
20	59.6	-.009	1126.7	1.400	96053.1	212.86	19485.	37.22

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	118.3	1.00	85.1	-.683E-01
2	54.4	117.1	1.59	632.5	.193E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
970.3	305.1	1.87	.116E+01	27030.	9226.	.00569

(EXPERIMENTAL K) RUN 719H, DATE 6/23/81, GAS H2 XE, MOLECULAR WT. = 28.97
TIN = 69.3 F, TOUT = 350.8 F, MASS FLOW RATE = 56.2 LB/HR, I = 124.8 AMPS, E = 3.120 VOLTS
PR,IN = .161, GR/RESC = .187E-02, MACH(2) = .081, MACH(16) = .096, T,SURR = 110.7 F, Q+(8) = .002051

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.062	199.3	1.202	51994.1	470.52	73916.	145.75
3	.3	.172	235.2	1.266	41727.3	286.63	73799.	88.70
4	.5	.056	257.1	1.303	46375.9	278.73	73652.	80.11
5	.8	.029	272.0	1.328	47663.5	264.56	73510.	81.60
6	1.3	.014	291.5	1.357	48430.0	245.54	73218.	75.46
7	2.2	.012	314.3	1.389	48616.5	224.82	72756.	68.69
8	4.3	.012	353.3	1.434	48758.1	198.47	71632.	59.73
9	7.7	.014	394.3	1.468	48816.4	179.76	69967.	52.84
10	10.8	.015	420.1	1.476	48861.1	172.61	68467.	49.65
11	17.4	.018	468.1	1.483	48672.2	162.00	65617.	44.66
12	23.9	.022	503.3	1.471	48808.2	158.61	63064.	42.00
13	30.5	.025	533.3	1.452	48771.8	158.26	60706.	40.31
14	37.0	.028	562.0	1.432	48717.9	158.48	58562.	39.01
15	43.6	.032	589.2	1.413	48650.9	159.25	56621.	37.91
16	48.0	.034	607.3	1.399	48598.6	160.04	55382.	37.31
17	52.4	.037	625.9	1.388	48532.3	160.32	54231.	36.60
18	56.6	.070	642.7	1.378	47079.8	156.31	53196.	34.99
19	58.7	.389	639.7	1.360	36275.2	124.97	52775.	27.75
20	59.3	.013	585.3	1.289	49526.6	212.09	52669.	46.97

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	115.4	1.00	88.5	-.569E-01
2	54.1	114.2	1.38	330.5	.109E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
469.7	185.1	1.44	.119E+01	63858.	32729.	.00486

(EXPERIMENTAL K) RUN 720H, DATE 6/23/81, GAS H2 XE, MOLECULAR WT. = 29.97
TIN = 97.3 F, TOUT = 540.0 F, MASS FLOW RATE = 54.9 LB/HR, I = 160.0 AMPS, E = 4.000 VOLTS
PR, IN = .181, GR/RESQ = .304E-02, MACH(2) = .080, MACH(16) = .103, T,SURR = 165.5 F, Q+(6) = .00344

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.071	282.7	1.335	86902.3	467.60	71174.	143.11
3	.3	.177	341.2	1.437	68837.7	283.26	70964.	86.55
4	.5	.054	378.5	1.499	77103.0	276.97	70747.	84.39
5	.8	.033	404.9	1.541	78799.5	260.13	70521.	79.04
6	1.3	.016	440.2	1.592	80341.9	240.39	70062.	72.59
7	2.2	.013	481.4	1.646	80818.6	219.03	69339.	65.46
8	4.3	.014	552.4	1.721	81190.2	191.73	67571.	55.89
9	7.7	.017	625.7	1.769	81366.2	172.70	65043.	46.49
10	10.9	.019	674.4	1.777	81451.7	164.46	62838.	44.62
11	17.4	.025	758.6	1.770	81434.2	153.92	58830.	39.06
12	23.9	.037	815.8	1.728	80802.4	150.59	55447.	36.10
13	30.5	.045	865.3	1.681	80502.4	150.23	52463.	34.14
14	37.1	.054	914.6	1.640	80102.8	149.60	49694.	32.34
15	43.7	.062	956.5	1.597	79703.1	150.93	47642.	31.02
16	48.1	.069	986.3	1.571	79357.7	151.34	46244.	30.27
17	52.5	.074	1010.1	1.542	79080.9	153.45	44978.	29.85
18	56.8	.110	1037.0	1.521	76669.6	149.90	43866.	26.39
19	58.8	.740	1031.5	1.497	48904.0	99.03	43453.	16.56
20	59.4	.008	935.5	1.396	83666.5	212.65	43360.	39.73

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	114.9	1.00	96.5	-.574E-01
2	54.3	113.3	1.53	507.2	.143E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
756.2	260.7	1.69	.152E+01	57855.	22657.	.00473

(EXPERIMENTAL K) RUN 721H, DATE 6/23/81, GAS H2 XE, MOLECULAR WT. = 28.97
TIN = 89.7 F, TOUT = 252.1 F, MASS FLOW RATE = 55.2 LB/HR, I = 97.8 AMPS, E = 4.890 VOLTS
PR,IN = .181, GR/RESQ = .110E-02, MACH(2) = .083, MACH(16) = .092, T,SURR = 104.5 F, Q+(8) = .001273

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.057	158.4	1.127	31674.2	456.63	72531.	141.92
3	.3	.162	179.0	1.163	25743.6	288.64	72461.	89.26
4	.5	.058	192.0	1.185	28291.3	278.84	72371.	86.14
5	.8	.022	200.2	1.199	29299.3	268.72	72285.	82.93
6	1.3	.013	211.6	1.216	29594.6	248.86	72106.	76.63
7	2.2	.011	224.7	1.235	29668.0	228.98	71823.	70.25
8	4.3	.011	247.3	1.262	29740.0	203.31	71117.	61.79
9	7.6	.012	270.8	1.283	29756.3	185.39	70075.	55.52
10	10.8	.013	286.7	1.290	29767.6	177.76	69111.	52.49
11	17.4	.015	314.4	1.298	29764.3	168.17	67229.	48.30
12	23.8	.017	335.6	1.294	29748.5	165.22	65483.	46.22
13	30.4	.019	353.9	1.285	29743.4	165.17	63820.	45.02
14	37.0	.021	373.2	1.279	29731.0	164.20	62253.	43.63
15	43.5	.022	391.1	1.271	29718.4	164.29	60800.	42.61
16	48.0	.024	403.9	1.267	29705.6	163.90	59645.	41.83
17	52.3	.025	416.1	1.262	29689.4	163.75	58950.	41.20
18	56.5	.053	425.6	1.255	28936.5	161.32	58131.	40.05
19	58.6	.241	421.7	1.241	24543.1	144.07	57777.	35.56
20	59.2	.010	391.4	1.196	30079.5	217.27	57684.	53.51

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	111.2	1.00	88.9	-.571E-01
2	54.0	110.2	1.26	239.2	.867E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
316.7	149.1	1.28	.971E+00	65567.	41801.	.00493

(EXPERIMENTAL K) RUN 722H, DATE 6/23/81, GAS H2 XF, MOLECULAR WT. = 28.97
TIN = 90.6 F, TOUT = 155.2 F, MASS FLOW RATE = 56.2 LB/HR, I = 62.8 AMPS, E = 3.140 VOLTS
PR,IN = .181, GR/RESQ = .411E-03, MACH(2) = .087, MACH(16) = .091, T,SURR = 95.3 F, Q+(b) = .000511

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.056	120.0	1.055	13010.8	437.08	73803.	135.03
3	.3	.167	128.2	1.070	10523.6	278.73	73775.	86.08
4	.5	.057	133.0	1.078	11626.5	274.65	73738.	84.79
5	.8	.018	136.1	1.083	12075.5	267.38	73703.	82.51
6	1.3	.015	140.6	1.090	12116.8	247.08	73629.	76.16
7	2.2	.010	145.0	1.096	12162.6	232.00	73513.	71.42
8	4.3	.011	153.9	1.107	12179.0	206.62	73220.	63.37
9	7.6	.012	163.1	1.117	12174.2	188.79	72771.	57.56
10	10.8	.012	169.3	1.121	12171.8	181.36	72355.	54.98
11	17.3	.014	179.9	1.125	12161.0	172.76	71527.	51.77
12	23.8	.017	188.7	1.126	12136.2	166.79	70726.	50.00
13	30.4	.018	196.1	1.124	12129.3	168.52	69932.	49.35
14	37.0	.020	204.8	1.125	12118.3	165.11	69158.	47.61
15	43.5	.021	212.7	1.125	12109.9	163.59	68421.	46.86
16	47.9	.022	218.1	1.125	12103.9	162.54	67925.	46.23
17	52.3	.023	223.5	1.125	12097.9	161.23	67446.	45.53
18	56.5	.044	229.0	1.125	11861.3	156.33	66998.	43.85
19	58.5	.163	228.1	1.120	10638.1	145.92	66796.	40.81
20	59.1	.024	216.7	1.100	12076.4	198.51	66740.	55.46

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	108.1	1.00	89.7	-.569E-01
2	54.0	107.3	1.12	149.9	.656E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
181.5	114.4	1.12	.768E+00	70529.	57310.	.00473

AD-A148 932 INTERNAL FORCED CONVECTION TO LOW PRANDTL NUMBER GAS MIXTURES(U) ARIZONA UNIV TUCSON ENGINEERING EXPERIMENT STATION M F TAYLOR ET AL. 15 JUL 84 1248-10 2/2

UNCLASSIFIED N00014-75-C-0694 F/G 20/13 NL

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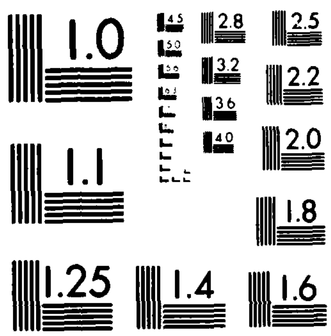

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

(CALCULATED K) RUN 7194, DATE 6/23/81, GAS H2 XF, MOLECULAR WT. = 28.97
TIN = 89.3 F, TOUT = 350.8 F, MASS FLOW RATE = 56.2 LB/HR, I = 124.8 AMPS, E = 3.120 VOLTS
PR,IN = .196, GR/RESQ = .202E-02, MACH(2) = .061, MACH(16) = .096, T,SURR = 110.7 F, Q+(R) = .002050

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COFF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.062	199.3	1.202	51994.1	470.57	73916.	157.60
3	.3	.172	235.2	1.266	41727.3	286.66	73799.	95.92
4	.5	.056	257.1	1.303	46375.9	278.75	73652.	93.15
5	.6	.029	272.0	1.328	47663.5	264.58	73510.	86.29
6	1.3	.014	291.5	1.357	46430.0	245.56	73218.	81.70
7	2.2	.012	314.3	1.389	48616.5	224.63	72756.	74.43
8	4.3	.012	353.3	1.434	48758.1	198.48	71632.	64.91
9	7.7	.014	394.3	1.468	48816.4	179.77	69967.	57.69
10	10.8	.015	420.1	1.476	48861.1	172.62	68467.	54.44
11	17.4	.018	468.1	1.483	48872.2	162.01	65617.	49.38
12	23.9	.022	503.3	1.471	48808.2	158.62	63064.	46.84
13	30.5	.025	533.3	1.452	48771.8	156.27	60706.	45.34
14	37.0	.028	562.0	1.432	48717.9	158.50	58562.	44.12
15	43.6	.032	589.2	1.413	48650.9	159.27	56621.	43.16
16	48.0	.034	607.3	1.399	48598.6	160.06	55382.	42.62
17	52.4	.037	625.9	1.388	48532.3	160.35	54231.	42.00
18	56.6	.070	642.7	1.378	47079.6	156.34	53196.	40.33
19	58.7	.389	639.7	1.360	36275.2	124.99	52775.	32.04
20	59.3	.013	585.3	1.289	49526.6	212.14	52669.	54.24

PT	X/D	STATIC PRESS,(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.0	115.4	1.00	88.5	-.569E-01
2	54.1	114.2	1.38	330.5	.109E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
469.7	185.1	1.44	.119E+01	63856.	32729.	.00456

(CALCULATED K) RUN 720H, DATE 6/23/81, GAS H2 XE, MOLECULAR WT. = 28.97
TIN = 97.3 F, TOUT = 540.0 F, MASS FLOW RATE = 54.9 LB/HR, I = 160.0 AMPS, E = 4.000 VOLTS
PR,IN = .156, CF/REFSQ = .329E-02, MACH(2) = .080, MACH(16) = .103, T,SURR = 165.5 F, Q+(8) = .003445

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.071	282.7	1.335	86902.3	467.63	71174.	155.03
3	.3	.177	341.2	1.437	68837.7	263.29	70984.	93.78
4	.6	.054	378.5	1.459	77103.0	276.98	70747.	91.49
5	.8	.033	404.9	1.541	78799.5	260.14	70521.	85.73
6	1.3	.016	440.2	1.592	80341.9	240.40	70062.	76.65
7	2.2	.013	481.4	1.646	80818.6	219.03	69339.	71.27
8	4.3	.014	552.4	1.721	81190.2	191.74	67571.	61.14
9	7.7	.017	625.7	1.769	81366.2	172.71	65043.	53.44
10	10.9	.019	674.4	1.777	81451.7	164.49	62838.	49.52
11	17.4	.025	758.6	1.770	81434.2	153.92	58830.	43.99
12	23.9	.037	815.6	1.728	80802.4	150.60	55447.	41.07
13	30.5	.045	865.2	1.681	80502.4	150.24	52483.	39.23
14	37.1	.054	914.6	1.640	80102.8	149.61	49894.	37.54
15	43.7	.062	956.5	1.597	79703.1	150.95	47642.	36.51
16	48.1	.069	986.3	1.571	79357.7	151.36	46244.	35.75
17	52.5	.074	1010.1	1.542	79080.9	153.47	44978.	35.44
18	56.8	.110	1037.0	1.521	76669.6	149.53	43666.	33.92
19	58.8	.740	1031.5	1.497	48904.0	99.05	43453.	22.23
20	59.4	.008	935.5	1.396	83866.5	212.69	43360.	47.62

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	114.9	1.00	96.5	-.574E-01
2	54.3	113.3	1.53	507.2	.143E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
756.2	260.7	1.69	.152E+01	57855.	22657.	.00473

(CALCULATED K) RUN 721H, DATE 6/23/81, GAS H2 XE, MOLECULAR WT. = 28.97
TIN = 89.7 F, TOUT = 252.1 F, MASS FLOW RATE = 55.2 LB/HR, I = 97.8 AMPS, E = 4.890 VOLTS
P2,IN = .196, GR/RESC = .119E-02, MACH(2) = .083, MACH(16) = .092, T,SUPR = 104.5 F, Q+(8) = .001273

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.057	158.4	1.127	31674.2	456.71	72531.	153.48
3	.3	.162	179.0	1.163	25743.6	288.68	72461.	96.54
4	.5	.058	192.0	1.185	28291.3	276.87	72371.	93.18
5	.8	.022	200.2	1.199	29299.3	268.75	72285.	89.72
6	1.3	.013	211.6	1.216	29594.6	248.69	72106.	82.93
7	2.2	.011	224.7	1.235	29688.0	229.00	71823.	76.07
8	4.3	.011	247.3	1.262	29740.0	203.33	71117.	67.01
9	7.6	.012	270.8	1.283	29756.3	185.41	70075.	60.39
10	10.8	.013	286.7	1.290	29767.6	177.78	69111.	57.26
11	17.4	.015	314.4	1.298	29764.3	166.19	67229.	52.97
12	23.6	.017	335.6	1.294	29748.5	165.23	65483.	50.94
13	30.4	.019	353.5	1.285	29743.4	165.19	63820.	49.89
14	37.0	.021	373.2	1.279	29731.0	164.22	62253.	48.62
15	43.5	.022	391.1	1.271	29718.4	164.31	60800.	47.74
16	48.0	.024	403.9	1.267	29705.6	163.93	59845.	47.03
17	52.3	.025	416.1	1.262	29689.4	163.78	58950.	46.43
18	56.5	.053	425.6	1.255	28936.5	161.35	58131.	45.23
19	58.6	.241	421.7	1.241	24543.1	144.09	57777.	40.19
20	59.2	.010	391.4	1.156	30079.5	217.32	57684.	60.51

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	111.2	1.00	88.9	-.571E-01
2	64.0	110.2	1.26	239.2	.887E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
316.7	149.1	1.26	.971E+00	65567.	41801.	.00493

(CALCULATED K) RUN 722H, DATE 6/23/81, GAS H2 XE, MOLECULAR WT. = 28.97
TIN = 90.6 F, TOUT = 155.2 F, MASS FLOW RATE = 56.2 LB/HR, I = 62.8 AMPS, E = 3.140 VOLTS
P2,IN = .196, GR/RESQ = .445E-03, MACH(2) = .087, MACH(16) = .091, T,SURR = 95.3 F, Q+(F) = .000511

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COFF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.056	120.0	1.055	13010.8	437.28	73803.	146.10
3	.3	.167	128.2	1.070	10523.6	276.83	73775.	93.14
4	.5	.057	133.0	1.078	11626.5	274.74	73738.	91.74
5	.8	.018	136.1	1.083	12075.5	267.46	73703.	89.26
6	1.3	.015	140.6	1.090	12116.8	247.15	73629.	82.44
7	2.2	.010	145.0	1.096	12182.6	232.06	73513.	77.31
8	4.3	.011	153.5	1.107	12179.0	206.67	73220.	68.63
9	7.6	.012	163.1	1.117	12174.2	186.83	72771.	62.39
10	10.8	.012	169.3	1.121	12171.6	181.40	72355.	59.66
11	17.3	.014	179.5	1.125	12161.0	172.80	71527.	56.30
12	23.8	.017	188.7	1.126	12136.2	168.83	70726.	54.51
13	30.4	.018	196.1	1.124	12129.3	166.56	69932.	53.92
14	37.0	.020	204.8	1.125	12118.3	165.15	69158.	52.35
15	43.5	.021	212.7	1.125	12109.9	163.63	68421.	51.42
16	47.9	.022	218.1	1.125	12103.9	162.59	67925.	50.80
17	52.3	.023	223.5	1.125	12097.9	161.28	67446.	50.10
18	56.5	.044	229.0	1.125	11861.3	156.38	66998.	48.31
19	58.5	.163	228.1	1.120	10638.1	145.96	66796.	44.96
20	59.1	.024	216.7	1.100	12076.4	198.58	66740.	61.15

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	108.1	1.00	89.7	-.569E-01
2	54.0	107.3	1.12	149.9	.656E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
181.5	114.4	1.12	.768E+00	70525.	57310.	.00473

RUN 723H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 86.6 F, TOUT = 146.8 F, MASS FLOW RATE = 57.3 LB/HR, I = 64.0 AMPS, E = 4.219 VOLTS
PR,IN = .717, GR/RESQ = .164E-02, MACH(2) = .089, MACH(16) = .094, T,SURR = 82.0 F, Q+(8) = .000480

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.095	133.1	1.087	14080.2	302.03	84169.	380.56
3	.3	.350	149.9	1.117	9449.8	149.53	84137.	188.38
4	.5	.122	159.9	1.135	11385.4	155.93	84103.	196.38
5	.8	.051	166.1	1.146	12155.4	154.01	84069.	193.89
6	1.3	.027	173.2	1.158	12444.3	145.62	84000.	183.18
7	2.2	.020	179.8	1.168	12536.2	137.48	83892.	172.70
8	4.3	.018	189.0	1.180	12568.0	128.08	83621.	160.31
9	7.6	.019	198.2	1.189	12563.9	121.01	83206.	150.62
10	10.8	.020	203.8	1.192	12563.2	118.31	82816.	146.49
11	17.3	.021	213.9	1.196	12552.4	114.73	82056.	140.53
12	23.8	.024	223.0	1.197	12525.8	112.15	81323.	135.92
13	30.4	.025	228.8	1.193	12522.9	113.15	80593.	135.67
14	37.0	.027	238.4	1.196	12508.3	110.36	79876.	130.96
15	43.5	.028	245.1	1.193	12502.0	110.32	79181.	129.56
16	47.9	.029	250.1	1.192	12495.8	109.95	78712.	128.22
17	52.3	.030	255.1	1.192	12488.6	109.49	78257.	126.81
18	56.5	.060	259.2	1.190	12132.5	106.56	77833.	122.64
19	58.5	.287	251.6	1.174	9989.1	95.71	77653.	109.63
20	59.1	-.012	221.4	1.123	12981.3	176.34	77613.	202.14

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	107.5	1.00	85.7	-.552E-01
2	54.0	106.7	1.19	142.0	.656E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
214.8	108.8	1.19	.798E+00	81126.	60191.	.00460

RUN 724H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 87.5 F, TOUT = 147.4 F, MASS FLOW RATE = 57.6 LB/HR, I = 63.8 AMPS, E = 4.214 VOLTS
PR,IN = .717, GR/RESQ = .198E-02, MACH(2) = .081, MACH(16) = .065, T,SURR = 84.3 F, Q+(8) = .000474

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.093	134.4	1.087	13984.4	297.42	84455.	374.13
3	.3	.347	151.1	1.117	9429.8	148.32	84423.	186.54
4	.5	.121	160.8	1.135	11334.8	155.37	84389.	195.34
5	.8	.043	166.5	1.145	12190.5	155.45	84356.	195.36
6	1.3	.028	173.6	1.156	12371.1	145.62	84287.	182.86
7	2.2	.019	179.7	1.166	12489.2	138.38	84180.	173.54
8	4.3	.018	188.9	1.178	12512.9	128.71	83910.	160.85
9	7.6	.019	198.1	1.167	12508.7	121.51	83498.	151.01
10	10.8	.019	203.6	1.190	12507.7	118.75	83110.	146.60
11	17.3	.021	213.4	1.193	12497.5	115.53	82360.	141.30
12	23.6	.024	221.6	1.193	12472.6	113.80	81632.	137.74
13	30.4	.024	227.4	1.189	12469.0	114.76	80906.	137.44
14	37.0	.026	236.5	1.191	12455.3	112.31	80193.	133.10
15	43.5	.027	242.8	1.188	12448.6	112.65	79502.	132.15
16	47.9	.028	246.4	1.185	12448.9	113.66	79036.	132.44
17	52.3	.029	253.2	1.188	12433.4	111.22	78582.	128.71
18	56.5	.059	257.3	1.166	12087.9	108.30	78160.	124.53
19	58.5	.273	249.3	1.169	10051.5	98.86	77981.	113.35
20	59.1	-.007	220.5	1.120	12855.3	177.79	77941.	203.64

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	118.8	1.00	86.8	-.552E-01
2	54.0	118.1	1.19	142.6	.632E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
213.9	109.5	1.18	.703E+00	81434.	60685.	.00462

RUN 725H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 88.4 F, TOUT = 236.3 F, MASS FLOW RATE = 57.9 LB/HR, I = 99.5 AMPS, E = 6.740 VOLTS
PR,IN = .717, GR/RESQ = .469E-02, MACH(2) = .082, MACH(16) = .091, T,SURR = 99.0 F, Q+(8) = .001156

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.091	203.6	1.212	34125.1	295.95	84778.	371.96
3	.3	.327	242.4	1.282	23436.5	152.50	84700.	191.58
4	.5	.108	265.6	1.323	28121.1	159.45	84616.	200.16
5	.8	.056	280.5	1.349	29536.3	154.92	84534.	194.31
6	1.3	.026	297.3	1.376	30443.9	147.75	84367.	184.95
7	2.2	.020	314.2	1.401	30662.6	138.86	84104.	173.24
8	4.3	.018	338.1	1.430	30770.2	128.59	83450.	159.06
9	7.7	.019	361.1	1.449	30782.3	121.29	82501.	148.05
10	10.8	.020	375.4	1.454	30790.7	118.46	81620.	142.78
11	17.4	.023	400.1	1.455	30774.8	114.80	79873.	134.91
12	23.9	.025	417.8	1.445	30737.5	114.17	78217.	130.90
13	30.4	.027	433.2	1.430	30720.7	114.70	76604.	128.34
14	37.0	.029	450.9	1.421	30692.0	114.19	75105.	124.99
15	43.5	.031	467.6	1.411	30662.0	113.99	73700.	122.25
16	48.0	.033	478.5	1.403	30642.5	114.12	72779.	120.72
17	52.4	.035	490.2	1.398	30611.0	113.72	71930.	118.71
18	56.6	.073	498.8	1.389	29546.6	110.53	71151.	113.97
19	58.6	.374	479.2	1.352	23037.7	94.70	70835.	97.11
20	59.2	-.007	412.0	1.252	31721.0	181.66	70771.	185.68

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	118.6	1.00	87.6	-.551E-01
2	54.1	117.6	1.39	224.7	.850E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
398.8	142.5	1.43	.959E+00	78205.	42556.	.00488

RUN 726H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 87.0 F, TOUT = 243.5 F, MASS FLOW RATE = 44.3 LB/HR, I = 89.8 AMPS, E = 5.930 VOLTS
PR,IN = .717, GR/RESQ = .476E-02, MACH(2) = .073, MACH(16) = .081, T,SURR = 103.5 F, Q+(8) = .001231

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.114	199.0	1.206	28503.4	254.36	64990.	320.30
3	.3	.427	235.9	1.273	17741.5	119.49	64930.	150.40
4	.5	.139	260.5	1.316	22280.6	129.16	64864.	162.44
5	.8	.071	276.3	1.344	23712.5	126.35	64798.	156.76
6	1.3	.034	294.8	1.374	24598.1	120.10	64663.	150.59
7	2.2	.024	313.1	1.401	24861.5	112.59	64448.	140.69
8	4.3	.022	338.6	1.433	24966.7	103.69	63916.	126.39
9	7.7	.024	363.7	1.454	24970.9	97.30	63143.	118.79
10	10.8	.025	378.9	1.459	24974.5	94.88	62428.	114.30
11	17.4	.028	405.5	1.460	24945.9	91.67	61014.	107.50
12	23.9	.031	424.0	1.449	24899.7	91.13	59678.	104.12
13	30.4	.033	439.9	1.433	24877.5	91.69	58380.	102.10
14	37.0	.037	461.2	1.427	24828.1	90.30	57187.	98.32
15	43.5	.039	476.6	1.413	24797.4	90.89	56063.	96.85
16	48.0	.041	487.9	1.405	24768.5	91.00	55344.	95.57
17	52.4	.044	499.1	1.397	24737.6	91.05	54666.	94.31
18	56.6	.094	509.5	1.390	23619.1	87.12	54048.	89.09
19	58.6	.509	486.0	1.348	17093.6	70.33	53809.	71.52
20	59.2	-.024	413.6	1.242	26280.9	155.28	53760.	157.53

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	101.6	1.00	86.5	-.586E-01
2	54.1	100.9	1.39	231.5	.886E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
404.1	144.3	1.43	.682E+00	55709.	32326.	.00504

RUN 727H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 86.6 F, TOUT = 148.8 F, MASS FLOW RATE = 45.0 LB/HR, I = 57.6 AMPS, E = 3.690 VOLTS
PR,IN = .717, GR/RESO = .177E-02, MACH(2) = .077, MACH(16) = .081, T,SURR = 89.5 F, Q+(8) = .000494

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.110	133.1	1.086	11614.2	249.15	66079.	313.82
3	.3	.423	148.5	1.114	7274.1	117.61	66054.	148.11
4	.5	.135	158.2	1.132	9123.0	128.09	66027.	161.25
5	.8	.054	164.3	1.142	9832.4	127.47	66000.	160.42
6	1.3	.039	172.3	1.156	9975.7	117.99	65945.	146.36
7	2.2	.022	178.5	1.165	10150.8	113.01	65858.	141.90
8	4.3	.021	188.1	1.178	10167.9	104.68	65638.	130.95
9	7.6	.022	197.3	1.187	10164.9	98.95	65303.	123.07
10	10.8	.023	203.4	1.190	10161.1	96.38	64987.	119.23
11	17.3	.025	213.5	1.193	10149.1	93.58	64375.	114.48
12	23.8	.028	222.1	1.194	10122.4	91.97	63784.	111.29
13	30.4	.029	228.9	1.191	10115.6	92.15	63195.	110.30
14	37.0	.031	237.5	1.191	10102.8	90.76	62618.	107.46
15	43.5	.033	245.2	1.190	10093.0	90.10	62058.	105.55
16	47.9	.034	250.6	1.190	10085.6	89.51	61680.	104.11
17	52.3	.036	256.1	1.190	10075.8	88.83	61314.	102.61
18	56.5	.072	259.7	1.187	9735.4	86.41	60975.	99.17
19	58.5	.359	251.2	1.169	7672.5	75.03	60834.	85.85
20	59.1	-.023	220.6	1.118	10648.0	149.92	60802.	171.36

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	97.6	1.00	85.9	-.583E-01
2	54.0	97.0	1.19	143.9	.675E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
214.2	109.5	1.18	.558E+00	63628.	47366.	.00496

RUN 728H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 79.5 F, TOUT = 365.3 F, MASS FLOW RATE = 23.1 LB/HR, I = 89.5 AMPS, E = 5.990 VOLTS
PR,IN = .719, GR/RESQ = .415E-02, MACH(2) = .078, MACH(16) = .094, T,SURR = 107.0 F, Q+(6) = .002358

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.188	233.6	1.288	30925.2	200.33	34149.	255.55
3	.3	.905	291.1	1.392	13244.0	62.79	34093.	80.02
4	.5	.210	332.6	1.467	20918.9	83.18	34035.	105.86
5	.8	.129	362.5	1.519	22466.6	80.17	33971.	101.87
6	1.3	.074	402.4	1.565	23680.5	74.56	33838.	94.38
7	2.2	.050	441.0	1.643	24299.9	69.04	33627.	86.82
8	4.3	.044	493.6	1.705	24520.3	62.29	33104.	77.00
9	7.7	.049	539.5	1.735	24485.9	57.96	32358.	69.78
10	10.8	.053	567.4	1.734	24445.1	56.32	31681.	66.14
11	17.4	.063	613.7	1.716	24303.1	54.36	30384.	60.80
12	23.9	.082	648.3	1.684	23915.3	53.26	29256.	57.16
13	30.5	.091	673.5	1.641	23764.5	53.83	28247.	55.55
14	37.1	.103	701.9	1.606	23559.2	53.87	27325.	53.38
15	43.6	.114	726.3	1.571	23374.0	54.37	26499.	51.91
16	48.1	.124	746.4	1.553	23190.3	54.14	25977.	50.52
17	52.5	.131	760.8	1.530	23071.0	54.71	25490.	50.08
18	56.7	.255	776.6	1.514	20817.7	49.75	25071.	44.72
19	58.7	2.212	716.1	1.429	6098.5	23.02	24958.	20.55
20	59.3	-.109	580.1	1.260	28908.9	135.44	24937.	120.48

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	49.3	1.00	78.8	-.682E-01
2	54.2	48.7	1.52	346.4	.137E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
607.9	186.5	1.65	.577E+00	29736.	12709.	.00642

RUN 729H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 80.8 F, TOUT = 253.9 F, MASS FLOW RATE = 23.6 LB/HR, I = 70.0 AMPS, E = 4.656 VOLTS
PR,IN = .719, GR/RESQ = .212E-02, MACH(2) = .085, MACH(16) = .096, T,SURR = 99.0 F, Q+(6) = .001400

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.175	176.9	1.180	18560.3	192.83	34946.	245.36
3	.3	.796	210.4	1.241	6549.2	66.13	34912.	64.10
4	.5	.215	235.8	1.286	12660.6	82.16	34876.	104.40
5	.8	.122	253.5	1.317	13731.6	80.28	34837.	101.91
6	1.3	.064	276.1	1.355	14508.5	75.50	34756.	95.62
7	2.2	.042	297.9	1.389	14830.0	70.15	34627.	88.49
8	4.3	.036	326.8	1.425	14955.1	63.96	34304.	79.86
9	7.6	.039	353.5	1.447	14943.5	59.67	33825.	73.33
10	10.8	.040	369.6	1.451	14936.4	58.14	33394.	70.36
11	17.4	.046	397.3	1.449	14888.9	56.24	32546.	66.05
12	23.8	.052	418.1	1.437	14824.7	55.72	31751.	63.56
13	30.4	.056	435.4	1.419	14786.5	56.12	30985.	62.23
14	37.0	.061	454.9	1.406	14731.7	55.96	30289.	60.54
15	43.5	.067	473.0	1.393	14678.1	56.04	29639.	59.20
16	48.0	.070	485.3	1.364	14638.4	56.11	29226.	58.35
17	52.4	.074	497.0	1.375	14596.5	56.23	28834.	57.58
18	56.6	.170	506.9	1.366	13412.2	52.06	28484.	52.53
19	58.6	1.168	472.1	1.309	7221.7	33.05	28369.	33.16
20	59.2	-.094	390.6	1.192	17178.9	126.76	28343.	126.84

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	46.5	1.00	80.0	-.678E-01
2	54.1	45.9	1.37	241.6	.107E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
396.1	144.8	1.42	.506E+00	31819.	17524.	.00614

RUN 730H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 81.2 F, TOUT = 153.2 F, MASS FLOW RATE = 23.5 LB/HR, I = 45.4 AMPS, E = 2.992 VOLTS
PR,IN = .718, GR/RESQ = .756E-03, MACH(2) = .092, MACH(16) = .097, T,SURR = 85.0 F, Q+(8) = .CC0586

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.171	120.5	1.074	7736.4	196.66	34765.	249.98
3	.3	.812	135.1	1.101	3544.0	65.91	34751.	83.76
4	.5	.203	145.7	1.120	5343.4	83.38	34736.	105.92
5	.8	.118	153.2	1.133	5753.0	80.66	34720.	102.43
6	1.3	.060	162.5	1.149	6074.7	75.96	34686.	96.36
7	2.2	.041	171.3	1.163	6188.6	70.50	34632.	89.29
8	4.3	.035	182.8	1.179	6230.7	64.54	34496.	81.39
9	7.6	.036	192.9	1.186	6228.7	60.83	34266.	76.19
10	10.8	.038	199.9	1.192	6221.2	59.04	34093.	73.47
11	17.3	.041	211.3	1.195	6204.3	57.17	33709.	70.22
12	23.8	.047	220.7	1.194	6174.0	56.24	33347.	68.20
13	30.4	.049	228.4	1.191	6163.4	56.44	32987.	67.57
14	37.0	.053	237.5	1.189	6147.8	55.88	32637.	66.06
15	43.5	.056	246.1	1.186	6133.7	55.51	32298.	64.62
16	47.9	.058	252.0	1.186	6124.0	55.26	32071.	63.99
17	52.3	.061	257.9	1.186	6112.4	54.93	31851.	63.10
18	56.5	.132	262.5	1.183	5727.7	51.70	31650.	58.95
19	58.5	.820	248.1	1.156	3559.0	37.67	31577.	42.82
20	59.1	-.095	212.3	1.096	7142.6	123.01	31559.	139.67

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.8	42.7	1.00	80.3	-.679E-01
2	54.0	42.2	1.18	147.9	.834E+00

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
211.8	108.0	1.18	.425E+00	33266.	24799.	.00607

RUN 731H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 81.2 F, TOUT = 475.3 F, MASS FLOW RATE = 22.9 LB/HR, I = 106.0 AMPS, E = 7.180 VOLTS
PR, IN = .718, GR/RESQ = .566E-02, MACH(2) = .079, MACH(16) = .100, T,SURR = 147.5 F, Q+(8) = .003333

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.195	311.6	1.428	44063.6	191.12	33882.	243.25
3	.3	.878	388.2	1.566	19002.7	62.11	33803.	78.94
4	.5	.201	444.7	1.666	29830.4	82.62	33721.	104.81
5	.8	.132	486.0	1.737	31741.8	79.22	33631.	100.27
6	1.3	.076	541.6	1.827	33533.9	74.07	33445.	93.25
7	2.2	.055	598.0	1.909	34324.2	68.23	33148.	85.10
8	4.3	.053	676.9	1.996	34603.2	61.10	32443.	74.40
9	7.7	.061	742.9	2.026	34485.4	56.71	31426.	66.56
10	10.9	.068	781.0	2.012	34373.5	55.17	30521.	62.59
11	17.4	.082	842.2	1.962	34053.9	53.44	28882.	57.06
12	23.9	.126	889.0	1.902	32824.6	51.42	27534.	51.97
13	30.5	.142	920.8	1.830	32445.0	51.91	26342.	49.68
14	37.2	.161	954.0	1.770	31987.6	52.12	25298.	47.74
15	43.7	.177	980.9	1.711	31600.4	52.92	24394.	46.44
16	48.2	.194	1004.2	1.681	31211.2	52.79	23826.	45.02
17	52.6	.206	1021.5	1.647	30933.0	53.31	23301.	44.35
18	56.8	.337	1040.3	1.622	27932.0	46.71	22852.	39.65
19	58.8	5.347	958.6	1.522	5852.3	12.08	22753.	9.76
20	59.5	-.103	778.0	1.324	40891.6	135.66	22740.	109.29

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	48.5	1.00	80.6	-.684E-01
2	54.3	47.8	1.64	451.1	.162E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
830.7	231.9	1.87	.690E+00	28509.	10036.	.00643

RUN 732H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 82.1 F, TOUT = 589.4 F, MASS FLOW RATE = 23.6 LB/HR, I = 123.4 AMPS, E = 8.331 VOLTS
PR,IN = .718, GR/RESQ = .727E-02, MACH(2) = .081, MACH(16) = .109, T,SURR = 200.5 F, Q+(8) = .004406

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.202	401.6	1.592	60646.8	189.68	34777.	241.28
3	.3	.867	500.6	1.770	26113.9	62.61	34669.	79.50
4	.5	.200	575.6	1.902	40845.7	83.33	34556.	105.54
5	.8	.135	630.5	1.995	43376.1	79.69	34433.	100.67
6	1.3	.083	705.7	2.113	45674.8	74.48	34179.	93.37
7	2.2	.062	781.3	2.218	46826.3	68.78	33781.	85.16
8	4.3	.064	888.0	2.323	47102.9	61.43	32846.	73.72
9	7.7	.079	978.6	2.350	46721.6	56.60	31510.	64.77
10	10.9	.088	1025.2	2.311	46485.6	55.25	30369.	60.66
11	17.5	.108	1098.1	2.211	45850.4	53.81	28398.	54.83
12	24.0	.183	1144.1	2.101	43106.2	51.36	26807.	48.79
13	30.6	.203	1176.3	1.993	42455.4	52.20	25470.	46.68
14	37.2	.223	1204.1	1.896	41841.5	53.33	24333.	45.29
15	43.6	.240	1226.7	1.809	41326.9	54.94	23336.	44.50
16	48.3	.259	1249.0	1.763	40755.4	55.26	22732.	43.37
17	52.7	.272	1263.8	1.715	40400.0	56.38	22179.	43.05
18	56.9	.386	1284.1	1.681	37119.3	52.71	21707.	39.26
19	59.0	*****	1186.3	1.574	3383.5	5.66	21616.	4.19
20	59.6	-.098	967.2	1.360	55843.9	148.75	21610.	109.54

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	48.5	1.00	81.4	-.679E-01
2	54.4	47.6	1.70	559.7	.183E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
1069.2	279.6	2.07	.825E+00	28400.	8512.	.00611

RUN 733H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 87.5 F, TOUT = 325.0 F, MASS FLOW RATE = 57.6 LB/HR, I = 125.2 AMPS, E = 8.230 VOLTS
PR,IN = .717, GR/RESQ = .786E-02, MACH(2) = .060, MACH(16) = .093, T,SURR = 122.0 F, Q+(8) = .001666

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.100	278.2	1.351	54874.7	287.44	84294.	362.00
3	.3	.339	339.6	1.461	37041.0	147.25	84170.	185.33
4	.5	.115	377.8	1.528	44627.4	154.52	84035.	194.24
5	.8	.059	402.0	1.570	47071.8	150.86	83903.	189.37
6	1.3	.029	430.9	1.616	48510.4	143.16	83636.	179.14
7	2.2	.023	460.8	1.660	48939.6	133.96	83214.	166.74
8	4.3	.021	503.8	1.710	49157.6	123.06	82202.	151.09
9	7.7	.024	542.9	1.737	49182.7	115.77	80713.	139.17
10	10.8	.025	563.5	1.734	49208.8	113.61	79352.	134.11
11	17.4	.028	601.8	1.721	49166.2	110.78	76698.	125.46
12	23.9	.036	632.3	1.697	48912.1	109.23	74301.	119.38
13	30.5	.039	655.3	1.664	48831.5	110.03	72088.	116.34
14	37.1	.043	680.0	1.635	48718.4	110.31	70092.	113.00
15	43.6	.047	699.6	1.603	48625.5	111.85	68228.	110.80
16	48.1	.050	714.8	1.584	48536.9	112.38	67021.	108.88
17	52.5	.053	728.3	1.565	48459.9	113.30	65926.	107.68
18	56.7	.095	741.9	1.549	46621.1	109.78	64931.	102.52
19	58.7	.497	712.3	1.498	34030.9	87.68	64547.	81.33
20	59.3	-.005	606.9	1.359	50851.0	181.20	64477.	167.60

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	120.4	1.00	86.8	-.552E-01
2	54.2	119.3	1.56	306.9	.103E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
598.8	174.6	1.67	.113E+01	74932.	31448.	.00462

RUN 734H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 89.7 F, TOUT = 418.2 F, MASS FLOW RATE = 58.1 LB/HR, I = 148.0 AMPS, E = 9.910 VOLTS
PR,IN = .717, GR/RESQ = .107E-01, MACH(2) = .081, MACH(16) = .099, T,SURR = 157.7 F, Q+(8) = .002597

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.107	355.1	1.465	77704.3	292.54	84742.	367.35
3	.3	.339	436.9	1.631	52154.5	150.60	84570.	188.93
4	.5	.112	489.7	1.723	63054.6	158.48	84379.	198.49
5	.8	.063	524.2	1.782	66112.2	153.40	84194.	191.75
6	1.3	.033	565.9	1.847	68223.7	145.25	83819.	180.77
7	2.2	.025	608.1	1.907	68978.1	136.02	83243.	168.05
8	4.3	.024	669.7	1.973	69305.3	124.57	81860.	151.03
9	7.7	.028	724.3	2.002	69332.9	117.18	79819.	137.98
10	10.9	.030	753.9	1.990	69347.0	115.00	77977.	131.78
11	17.4	.035	807.7	1.958	69232.2	111.63	74524.	121.80
12	23.9	.053	855.7	1.922	68326.6	108.44	71554.	112.96
13	30.5	.059	887.1	1.867	68079.9	109.08	68861.	108.51
14	37.1	.067	922.4	1.822	67740.0	108.85	66446.	103.70
15	43.7	.076	960.3	1.787	67317.1	107.91	64276.	99.20
16	48.2	.083	985.9	1.764	66989.1	107.26	62906.	96.31
17	52.6	.088	1003.6	1.734	66779.9	108.05	61668.	94.68
18	56.8	.136	1028.4	1.718	64034.3	103.24	60552.	88.49
19	58.8	.776	974.9	1.640	40827.6	73.17	60159.	62.15
20	59.5	-.015	822.0	1.460	72871.7	181.19	60103.	153.24

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	120.3	1.00	89.0	-.551E-01
2	54.3	118.9	1.73	394.1	.121E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
806.6	211.4	1.89	.135E+01	73020.	25172.	.00476

RUN 735H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 90.6 F, TOUT = 506.0 F, MASS FLOW RATE = 58.9 LB/HR, I = 166.0 AMPS, E = 11.340 VOLTS
PR, IN = .717, GR/RESQ = .136E-01, MACH(2) = .081, MACH(16) = .103, T,SURR = 198.0 F, Q+(8) = .003317

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.114	432.7	1.624	101592.7	296.81	85824.	372.43
3	.3	.356	537.3	1.810	66820.0	149.94	85599.	187.91
4	.5	.101	606.6	1.930	82729.6	161.20	85349.	201.60
5	.6	.076	656.2	2.014	84943.9	151.41	85105.	188.90
6	1.3	.039	714.2	2.104	88309.3	143.51	84620.	176.07
7	2.2	.029	771.0	2.182	89572.1	134.51	83891.	165.35
8	4.3	.030	856.1	2.269	89955.3	122.35	82113.	146.84
9	7.7	.036	928.6	2.297	89930.6	114.86	79524.	132.89
10	10.9	.040	970.5	2.278	89858.4	112.13	77218.	125.40
11	17.5	.048	1040.7	2.220	89536.3	106.76	73109.	114.61
12	24.0	.079	1093.1	2.146	87309.2	105.37	69636.	104.83
13	30.6	.088	1127.7	2.062	86791.8	106.35	66588.	100.27
14	37.2	.098	1163.3	1.988	86164.9	107.02	63886.	96.57
15	43.8	.103	1180.7	1.903	85675.9	110.57	61553.	95.30
16	48.3	.111	1204.6	1.864	85382.8	110.97	60054.	92.96
17	52.7	.118	1224.2	1.824	84981.3	112.01	58679.	91.46
18	56.9	.155	1241.7	1.788	82322.4	110.08	57501.	87.60
19	59.0	1.003	1184.2	1.709	47298.5	69.59	57102.	54.87
20	59.6	-.015	999.5	1.511	95027.5	193.33	57059.	151.74

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	122.2	1.00	89.9	-.550E-01
2	54.4	120.6	1.81	476.3	.136E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
1025.4	245.8	2.10	.154E+01	72075.	20887.	.00455

RUN 736H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 84.8 F, TOUT = 385.0 F, MASS FLOW RATE = 43.8 LB/HR, I = 123.6 AMPS, E = 8.210 VOLTS
PR, IN = .718, GR/RESQ = .893E-02, MACH(2) = .075, MACH(16) = .090, T,SURR = 139.5 F, Q+(8) = .002400

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.129	307.4	1.411	55358.9	246.48	64311.	314.35
3	.3	.459	378.6	1.539	33237.8	113.41	64194.	143.34
4	.5	.147	426.4	1.623	42438.5	124.93	64067.	157.67
5	.8	.062	457.1	1.676	45912.9	124.37	63939.	156.69
6	1.3	.050	500.5	1.747	46602.2	113.70	63675.	142.68
7	2.2	.029	537.3	1.799	47682.6	107.81	63267.	134.38
8	4.3	.029	595.0	1.866	47857.7	97.92	62282.	119.93
9	7.7	.033	646.0	1.897	47848.8	91.65	60845.	109.26
10	10.9	.035	673.4	1.890	47845.5	89.81	59544.	104.40
11	17.4	.041	721.5	1.863	47723.4	87.35	57060.	96.67
12	23.9	.057	760.3	1.827	47128.2	85.47	54902.	90.74
13	30.5	.064	788.7	1.779	46934.4	86.03	52975.	87.71
14	37.1	.071	817.1	1.735	46704.2	86.49	51191.	84.44
15	43.6	.078	842.3	1.693	46484.4	87.38	49624.	82.25
16	48.1	.085	863.6	1.672	46265.6	87.21	48612.	80.33
17	52.5	.090	881.3	1.648	46088.9	87.63	47672.	79.07
18	56.7	.152	900.3	1.630	43682.0	83.30	46867.	73.61
19	58.8	.909	852.2	1.558	26269.7	56.08	46589.	49.15
20	59.4	-.038	710.4	1.385	51591.8	159.17	46547.	138.96

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	97.9	1.00	84.2	-.587E-01
2	54.2	96.9	1.64	363.3	.121E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
716.4	195.9	1.79	.940E+00	55851.	20866.	.00517

RUN 737H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 85.3 F, TOUT = 329.2 F, MASS FLOW RATE = 45.1 LB/HR, I = 112.8 AMPS, E = 7.492 VOLTS
PR,IN = .718, GR/RESQ = .680E-02, MACH(2) = .077, MACH(16) = .091, T,SURR = 131.5 F, Q+(8) = .001934

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.117	271.8	1.344	45394.5	243.15	66215.	307.31
3	.3	.425	329.4	1.448	28242.6	115.97	66118.	146.46
4	.5	.127	366.6	1.514	35794.3	127.90	66012.	161.34
5	.8	.075	391.9	1.557	37618.8	123.70	65905.	155.61
6	1.3	.038	422.7	1.607	39034.0	117.30	65689.	147.28
7	2.2	.027	453.1	1.652	39550.1	109.99	65348.	137.33
8	4.3	.025	497.0	1.703	39744.8	100.77	64518.	124.05
9	7.7	.027	537.0	1.731	39756.2	94.60	63310.	113.93
10	10.8	.029	560.3	1.731	39760.3	92.44	62205.	109.07
11	17.4	.034	600.5	1.719	39697.6	89.71	60059.	101.59
12	23.9	.043	631.9	1.695	39443.6	88.33	58127.	96.43
13	30.5	.047	654.9	1.659	39354.5	89.07	56353.	94.00
14	37.1	.052	680.0	1.630	39230.0	89.29	54751.	91.21
15	43.6	.056	701.4	1.598	39123.4	90.26	53259.	89.05
16	48.1	.062	721.9	1.586	38986.1	89.54	52302.	86.41
17	52.5	.065	737.6	1.569	38888.3	89.62	51428.	84.99
18	56.7	.121	751.6	1.553	36982.2	85.99	50640.	79.98
19	58.7	.660	712.8	1.490	24908.2	64.79	50351.	59.86
20	59.3	-.029	599.3	1.342	42260.9	157.21	50300.	144.83

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	97.3	1.00	84.6	-.583E-01
2	54.2	96.4	1.56	311.1	.109E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
596.8	175.0	1.66	.902E+00	58679.	24733.	.00516

RUN 738H, DATE 6/29/81, GAS AIR , MOLECULAR WT. = 28.97
TIN = 85.7 F, TOUT = 550.6 F, MASS FLOW RATE = 43.8 LB/HR, I = 155.2 AMPS, E = 10.500 VOLTS
PR,IN = .718, GR/RESQ = .140E-01, MACH(2) = .074, MACH(16) = .097, T,SURR = 201.0 F, Q+(6) = .003816

TC	X/D	HL/QGAS	TW (F)	TW/TB	QGAS BTU/HRFT2	H T COEF BTU/HRFT2F	BULK REYNOLDS	BULK NUSSELT
2	.1	-.142	435.9	1.645	89521.5	255.44	64199.	323.05
3	.3	.482	544.4	1.839	52207.5	114.13	64012.	144.13
4	.5	.140	620.1	1.971	68221.1	128.38	63809.	161.76
5	.8	.086	672.3	2.059	71884.6	123.61	63604.	155.32
6	1.3	.052	739.4	2.164	74581.5	115.74	63188.	144.52
7	2.2	.038	805.3	2.255	75909.4	107.93	62551.	133.35
8	4.3	.041	903.0	2.353	76223.1	97.37	61035.	117.03
9	7.7	.050	984.3	2.378	76000.4	90.91	58848.	104.60
10	10.9	.052	1014.6	2.326	76001.1	90.53	56940.	100.48
11	17.5	.064	1086.9	2.246	75503.3	88.11	53580.	91.49
12	24.0	.108	1142.9	2.161	72753.4	84.62	50770.	82.29
13	30.6	.120	1175.1	2.058	72179.4	86.02	48376.	79.27
14	37.2	.133	1209.9	1.973	71464.4	86.95	46300.	76.15
15	43.8	.144	1235.6	1.890	70922.2	89.02	44467.	74.35
16	48.3	.157	1262.3	1.849	70261.7	89.06	43327.	72.22
17	52.7	.162	1275.3	1.798	69976.0	91.06	42313.	71.72
18	56.9	.212	1292.9	1.760	67174.7	88.99	41408.	68.43
19	59.0	1.717	1220.5	1.669	29826.9	44.41	41135.	33.84
20	59.6	-.040	1017.2	1.462	83267.3	179.19	41107.	135.90

PT	X/D	STATIC PRESS.(PSIA)	TW/TB	TB (F)	PRESS DEFECT
1	-5.9	98.1	1.00	85.1	-.588E-01
2	54.4	96.9	1.78	519.1	.150E+01

AVERAGE PARAMETERS FROM START OF HEATING TO PT2

TW,AV(F)	TB,AV(F)	TW,AV/TB,AV	DELTA P(PSI)	RE,B,AV	RE,W,MOD,AV	F,B,AV
1071.3	261.5	2.12	.116E+01	53119.	15219.	.00476

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